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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

SEPTEMBER 24-OCTOBER 6.

World Power Conference:—Fuel conference at Imperial Institute, London.

OCTOBER 11-20.

Motor Exhibition at the Olympia, London, W.

Institute of British Foundrymen.

SEPTEMBER 29.

Newcastle and District Branch:—Opening meeting at Newcastle-on-Tyne. Presidential address.

OCTOBER 6.

Wales and Monmouth Branch:—Smoking concert at Cardiff.
Lancashire Branch:—Opening meeting at Manchester. Presidential address by E. Longden. Lecture by Professor F. Johnson, D.Sc., on "Oxygen and Metals: Some Features in their Relationship."

OCTOBER 13.

Lancashire Branch (Burnley Section):—Opening meeting at Burnley. "Practical Application of Science to Motor Cylinder Making." Paper by W. West, of the Leyland Motors, Limited.

Patent Law Reform.

We give an account in this issue of those of the Papers likely to interest our readers, presented to the week-end Conference recently held by the Association of Special Libraries and Information Bureaux.

The programme indicates the extraordinary catholicity of subjects, and yet further that there is a unifying central idea, for they are all subjects which either do or should interest the business man whose ideas are not confined to a narrow rountine of production, accounting or selling.

One Paper, by Dr. A. P. Thurston, on Patent Law Reform attracted a discussion in which inventors, manufacturers and patent agents and examiners took part. Dr. Thurston's main suggestions were that people who wish to publish an invention for the express purpose of preventing subsequent patenting by other people should be permitted to take out a specification for "deposited invention" for a small fee. It is well known that this situation frequently arises in practice. He also suggested that comparatively small patents which are at present discouraged on account of the size of the fees, specially for renewal, might be provided for by a sort of minor specification, after the German system. The most important proposal of all, however, arose from the fact that paper anticipation of a new invention can often be cited, in spite of the fact that no effective prior manufacture has ever taken place. We are all familiar with the case of the inventor who finds his specification hampered because somebody else previously had failed practically, and yet had left on record statements which might be held to constitute an anticipation.

Dr. Thurston's proposal here was that the search for novelty should be limited. Instead of the current 50 years' search through prior specifications, he proposed six years, on the ground that if a patent has not been anticipated in manufacture six years before filing the provisional, then anticipation must be purely paper anticipation and not real anticipation.

We do not, however, share this view. Experience with patents has convinced us that the British patent specification, when granted, is weak, not because the search for novelty has been too extensive, but because it has not been extensive enough. The search is confined by the Patent Office examiner to patent specifications, whereas anticipation is frequently to be found in technical literature generally. It is very difficult to interest a capitalist or financier in a British invention for the simple reason that the British specification really carries no guarantee of its own validity. There cannot, of course, in the nature of things be an absolute guarantee, for even officials are human, and the only ultimate criterion is the High Court; at the same time, there seems no reason why the search should not be as complete as possible.

One aspect which does not appear to have been touched on is the fact that Patent Law was originally designed for improvements of a mechanical nature embodied in devices or machines or engines. To-day many patents are taken out based on discoveries rather than inventions. To-day, instead of machine parts, we find patent specifications containing equilibrium diagrams, micro-structures and other weird adjuncts, and we have to deal with such controversial questions as to whether a particular mixture of known metals or a particular method of heat treatment can be in fact patented.

Patent specifications tell the world at large what it is in fact prevented from doing, but it seems to us very important that there should be some means of telling the manufacturer in addition what he is permitted to do without hindrance.

The World Fuel Conference.

The World Fuel Conference which opened last Monday at the Imperial Institution has special significance for the foundry industry, as a much higher proportion of the world's fuel than is generally realised is consumed in the remelting of metals. Moreover, foundries use every type of fuel—coal, coke, oil, gas and electricity, all of which are receiving intense study at this convention.

When the new order of affairs is established, as can be imagined from a study of the Papers presented, will cast iron be melted by the residual "semi"-coke; by coal-oil; by gas; or by electricity generated under large scale conditions in "super" power stations? We have reached the conclusion that all four methods will be utilised, the governing conditions will remain as they are to-day: Quality of the iron; continuity of supply; weight to be dealt with; and cost considerations as influenced by locality.

Apart from this "peep into the future" aspect of the Fuel Conference, there is a more intimate contact with the industry, in so far as it discloses tendencies soon likely to be embraced or recently adopted by the "fuel" industry. Each one of these reacts upon the founder, either by increased demands upon his skill or capacity; by providing new forms of fuel or orienting the mode of application of an old one (as in the case of pulverised fuel), and finally by indicating clearly where the wise may look for increased business.

It is this last phase which is the most important for the moment, as these developments—as do all other industrial developments—carry in their train a demand for fresh types of castings or an increased demand for existing types. As a concrete example we may cite the large quantities of joint boxes and other electrical castings now being ordered under the new national electricity schemes. Again, better types of retort covers have been successfully experimented upon by the Fuel Research Board, involving a higher grade of cast iron than that normally used.

Thus it is patent that the World Fuel Conference is a movement in which the British foundry industry must necessarily take the closest interest and be prepared to act upon the trend of affairs as disclosed thereby.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Employers and the Schools.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I was interested personally in reading the second of your leaders that appeared in your journal of September 20, 1928, viz., *Employers and the Schools*. The apathy shown in these matters is hardly at times to be believed, and makes one think that many employers of labour do not appreciate or think there can be any advantage in any special education or the fostering of the youths in subjects that give so much grip, especially in the foundry. Thus I am tempted at this juncture to give of my own experience that has dominated my own career, even in later life, through having incidentally taken a post at one of our colleges that cater for the instruction of students in up-to-date foundry work of a practical nature combined with the necessary theory. I have myself in the past, written a fair number of foundry articles for THE FOUNDRY TRADE JOURNAL, and taken evening classes at several London colleges and during the daytime been in charge of foundries, and afterwards had the management of several leading foundries in the provinces for many years, being a practical man who gave up much time to the theory of his business. When I had the offer to superintend the foundry work and classes at a well-known college for some years, judge of my surprise when I later applied for another post with a commercial firm, which was many times repeated and many interviews, with some thousand of miles travelled to see employers. At these interviews I was from time to time soon led to understand that I had made a fatal mistake in going from the beaten track, or in interesting myself outside the realms of the ordinary foundry. Surely one would think some employers would have vision enough to reinstate and employ, but such seems the feeling that having also taken an interest theoretically and gone outside the works one is looked upon as incapable of taking charge again. This is on a par with the attitude you are now stressing in the leader cited.—Yours, etc.,

BOTH PRACTICAL AND THEORETICAL.

[We totally disagree with our correspondent, as we are in a position to enumerate numerous cases of prominent people in the industry who have benefited materially from having spent a period of their career as lecturers or instructors in technical colleges. The appeal in our leader was definitely addressed not to individuals but to their trade organisations, as personal views are of but little value to national committees and commissions.—EDITOR.]

Seventh National Cost Conference.

The Seventh National Cost Conference of the Institute of Cost and Works Accountants will be held at the Queen's Hotel, Birmingham, to-morrow, September 28.

At the morning session, commencing at 10.30 a.m., Mr. Alexander Ramsay (Chairman of the Birmingham and District Engineering and Allied Trades Employers' Association) will preside, and the subject of "Cost Accounting and the Industrial Future" will be introduced by Mr. J. A. Lacey, F.C.W.A. (Birmingham), and Mr. J. Wardropper, B.Sc. (York).

The subject of "The Standardisation of Cost Accounts" will be introduced by Mr. B. Thistlethwaite, F.C.W.A. (Manchester), at the Afternoon Session, at 2.30 p.m., when Sir Holberry Mensforth, K.C.B., C.B.E., will preside.

The attendance of directors, managers, executives, cost accountants and other responsible works officials is cordially invited.

The annual dinner of the Institute will take place at 7.15 p.m. on the same day at the Queen's Hotel, Birmingham, when the chief guest will be the Rt. Hon. Lord Askwith, K.C.B., K.C.

The Aslib Conference.

The fifth annual Conference of the Association of Special Libraries and Information Bureaux was held at New College, Oxford, during the week-end, September 14 to 17, about 180 members and visitors participating. This conference is always held in the peaceful seclusion of one of the ancient foundations, and owes its particular character and charm largely to this.

Among a wide range of organisations represented were the National Federation of Iron and Steel Manufacturers, the North-East Coast Institution of Engineers and Shipbuilders, the Cast-Iron and Non-Ferrous Research Associations, the Cleveland Scientific and Technical Institution, the D.S.I.R., and N.P.L., and the Institute of Metals. Mr. J. G. Pearce acted as chairman of the Conference.

At the opening session Dr. R. S. Hutton dealt with the work of Aslib during the year, with special reference to its incorporation and to the completion of the Aslib Directory. A subsequent Paper by Dr. A. P. Thurston on "Patent Law Reform" has been dealt with on our leader page.

Major L. Urwick, O.B.E., opened a very useful discussion on "The Literature of Scientific Management" with a very able contribution. Major Urwick has recently been appointed a director of the International Institute of Scientific Management at Geneva.

An interesting informal discussion took place on indexes to technical periodicals, to which editors of two leading engineering journals contributed, and Mr. F. M. Earle, of the National Institute of Industrial Psychology opened a discussion on "Vocational Selection and Guidance."

Perhaps the most important session was opened by Dr. W. Rosenhain, of the National Physical Laboratory, with a Paper on "Scientific Abstracts." We shall return to this matter on another occasion. Representatives of the National Safety First Association and several Government departments dealt with "Information on Accident Prevention."

Colonel Sir Henry Lyons, F.R.S., Director of the Science Museum in South Kensington, presented a Paper on the "Standardisation of Bibliographical Methods," and at the concluding session a representative of the Carnegie Trust dealt with the Aslib Directory to sources of information.

The Papers likely to be of interest are too lengthy to be considered even briefly, but readers who are interested can obtain copies from the Aslib Secretary, 26, Bedford Square, London, W.C.2.

Applications for Trade Marks.

The following applications to register trade marks are extracted from the "Trade Marks Journal":—

"ALUMBRO."—Metals. Muntz's Metal Company, Limited, Selly Oak Works, Birmingham.

"FIRTHS TAYBRITE."—Stainless steel. Thos. Firth & Sons, Limited, Norfolk Works, Sheffield.

"JALCASE."—Metals. Hall & Pickles, Limited, 43, Arundel Street, Sheffield.

"KUDOS."—Machinery. Smith & Wellstood, Limited, Bonnybridge, Scotland.

"VOLUFLUX."—Pumps. A. C. Potter & Company, Dysart Road Ironworks, Grantham.

Applications made to the Cutlers' Company, Sheffield.

"TEAZER."—Metals. Hall & Pickles, Limited, 43, Arundel Street, Sheffield.

"PERAX."—Steel. Marsh Brothers & Company, Limited, Shude Lane, Sheffield.

"KELOCK BETA."—Steel. Kayser Ellison & Company, Limited, Carlisle Street East, Sheffield.

THE STRIKE at the Tata iron and steel works at Jamshedpur, which began in April and culminated last June in a general lock-out, has been settled as the result of protracted negotiations between the board of directors and the Swarajist leader, Mr. Subas Chandra Bose. All the men will be re-employed as far as possible, and those for whom there is no regular work available, will be given preference over outsiders in filling up future vacancies.

Random Shots.

My invitation last week to readers to send an occasional good story was not intended to be confined to any particular type of yarn. I should be particularly pleased, however, to hear a few really good foundry stories; there must be a lot, and, with the winter coming on, quite a number of readers will be grateful for material which will enable them to make an acceptable after-dinner speech. By foundry stories, of course, I mean stories about founders or founding, not stories which are only fit to be told in the smoking-room. Many readers will remember, for example, the story told by a past-president of the I.B.F. of the man who accepted a contract to make a cast-iron boiler for the local workhouse. For reasons which are best left undisclosed, the first attempt was a fiasco, and so was the second. As the third mould was being prepared, the proprietor was heard to mutter nervously, "I hope this one's all right; if it ain't I shall be in t'workus afore boiler." It will help if you put "Marksman" on your postcard or envelope and send it to the Editor. If your effort is printed you can consider it a "bull's-eye," or, at any rate, an "inner."

* * *

Personally I must confess to a distinct weakness for what can only be described as American humour. It is, as a rule, quite different from English humour; it depends for its effects on exaggeration, but it shows itself at its best in that brief, succinct statement, which can be boiled down to eight or ten words, and yet which contains a laugh. Some of the highest paid journalists in America have an output inversely proportional to their salaries, because their sole contribution to a day's issue of a newspaper will be half-a-dozen "peppy" remarks, which are invariably topical, frequently personal, and usually highly amusing. It is perfectly true that some of these American expressions are not at all humorous to English readers, for the simple reason that they deal with an aspect of American life with which we are not familiar; indeed, I have met American jokes which would merely create a vacant stare in an English audience. The fertility of invention in new words is doubtless responsible for the notice which can occasionally be seen in Paris, "English spoken here—American understood."

* * *

The disrespect for personalities, which almost amounts to irreverence, is somewhat distasteful to English readers, but in these days of speed there is no doubt that American humour is becoming more popular on this side. Perhaps nothing has done more to popularise it than the "strip comic" now so much featured in this country, in which the whole of the fun lies in the text rather than in the pictures. The inside pages of an American newspaper will often consist of nothing else but these strips, and the newspapers are bought for the excellence of their comics rather than the quality of their leaders or news.

* * *

Some day I shall have to attempt a classification of stories, because some people say that there are only five stories in the world. The differences between the subtle and the broad about the same subject is well illustrated by those about the harmless, necessary waiter. A very bored diner at a club one evening turned to the waiter and asked, "Waiter, is this soup tomato or ox-tail?" "Cannot you tell, sir, from the taste?" said the waiter persuasively. "If I could tell from the taste would I ask you what it was?" "Then," returned the waiter blandly, "if you cannot tell from the taste, sir, does it really matter?"

* * *

The other one concerns a waiter who came along to a diner in a much less pretentious establishment for the purpose of making up his bill. "Let me see, sir," said the waiter. "Did you have ox-tail or tomato soup?" "Well, I really don't know," said the diner. "What I had tasted like soap-suds." "Then that must be the ox-tail, sir, because the tomato tastes like paraffin."

MARKSMAN.

The Use and Interpretation of the Transverse Test for Cast Iron.*

By J. C. Pearce, M.Sc. (Director British Cast Iron Research Association).

Introduction.

The transverse test remains by far the simplest and most generally used test for cast iron. It can be made with little expenditure of time on a simple unmachined bar on a cheap and easily manipulated machine. The breaking load and deflection figures obtained are readily understood.

Square and rectangular bars have hitherto been commonly used for this test, but the recent British Engineering Standards Specification for grey cast iron[1] (No. 321, 1928) specifies for the first time in this country a cylindrical transverse bar. A greater degree of uniformity in results from similar bars of the same composition is assured if they are skin-machined, as minute skin-fissures and cracks may induce premature fracture in particular bars, and hence lead to erratic results, particularly from green-sand moulds. Since the outer layers of the bar are the strongest, the removal of more metal than is required to give a clean unbroken surface will in ordinary irons lead to a reduction in strength. Skin-machining, on the other hand, for the reason given, is generally found to increase rather than diminish the strength. Machining invariably results in improved deflection.

Current methods of using the results of the transverse test do not yield the whole of the information that this test is capable of giving, and the object of this Paper is to suggest an alternative method of treatment.

A method frequently used in foundries and engineering shops is to report the actual breaking load, irrespective of the actual section, on the assumption either that the cast and normal sizes are identical or that small variations between them do not cause appreciable error. Since it is virtually impossible accurately to cast a specified diameter, and since strength changes very rapidly with small dimensional changes, this method is open to grave errors, and may indeed give results which are contrary to the facts. This mode of expression also precludes comparison between transverse and other specific stresses, such as tensile, compression, shear, and torsion, or between transverse bars of other shapes and sizes of the same material.

The method more commonly used in general working and in technical literature, and usually recommended in text-books, is that of converting by formula the breaking load at the cast size into a breaking load at the nominal or specified size. This procedure cannot be justified except for very small variations, and the nature of the error involved can be seen by a consideration of the rupture modulus as a criterion of transverse strength.

Modulus of Rupture.

The formulæ for the strength of cast-iron transverse bars are based on the hypothetical case of the weightless, end-supported, centrally-loaded beam. For supports L in. apart and a central load of W lb., by beam theory the bending moment at the centre is $\frac{WL}{4}$. The resistance offered by the beam depends upon its size and shape, and may be expressed as fZ, where f is the specific resisting stress set up in the beam and Z is a constant for a given bar (the section modulus), taking into account the size and shape of the section. Within the elastic limit $fZ = \frac{WL}{4}$. The formula ceases to be strictly true when the elastic limit is passed, but it is convenient to measure the stress f at fracture by means of the value $\frac{WL}{4Z}$. The stress f then becomes the so-called modulus of rupture, although it might preferably, if more clumsily, be termed the "ultimate bending strength" (U.B.S., similar to ultimate tensile strength, U.T.S.) or "ultimate breaking strength by bending." For a standard bar $\frac{L}{4Z}$ is constant, and then $f = KW$. For accurately cast bars the conversion from breaking load to rupture modulus is thus simple, and a straight-line graph can be used. This conversion, of course, does not hold for bars not cast or machined accurately to specified size, for the modulus Z depends upon bar dimensions. Graphs can, however, be readily prepared covering variations in diameter of cylindrical bars, and the arithmetical objection is then removed.

The modulus of rupture may be regarded as a criterion of the bending strength of a particular bar, for it takes into account the dimensions of the bar itself. It affords a means of comparing the strengths of similar bars of different compositions and of different bars of similar compositions. The rupture modulus has the greatest significance as a simple means of determining a change of strength with section. It is a useful index to the influence of rate of cooling. The conversion procedure usually recommended for obtaining the strength of a cast bar in terms of the dimensions of a standard bar is based on the following reasoning:—

Take, for example, the standard rectangular bar of breadth and depth d; the modulus $Z = \frac{bd^2}{6}$,

whence $$f = \frac{3WL}{2bd^2}$$

Consider a cast bar of actual breadth b_1 and actual depth d_1 breaking at W_1.

Then $$f = \frac{3W_1L}{2b_1d_1^2}$$

Hence $$\frac{3WL}{2bd^2} = \frac{3W_1L}{2b_1d_1^2}$$

from which the required load W for the specified dimensions b and d becomes

$$\frac{W_1bd^2}{b_1d_1^2}$$

Alternately, for the new standard round bars (B.E.S.A. Specification 321, 1928) of diameter d,

$$Z = 0.0982d^3, \text{ and } f = \frac{WL}{0.39d^3}$$

If the cast diameter is in fact d_1 breaking at W_1,

then $$f = \frac{W_1L}{0.39d_1^3}$$

Hence the required breaking load W for a standard diameter is

$$\frac{W_1d^3}{d_1^3}$$

The fallacy involved in the above reasoning lies in the assumption that f remains the same for the cast as for the specified diameters. This might be true for homogeneous materials, but is not true for cast iron. The closer the cast to the specified size the smaller is the error involved, but for ordinary casting tolerances the variation is too great to be ignored. Fig. 1 shows an illustrative case in which the three diameters of standard cylindrical bars are plotted against actual rupture moduli for three series of bars, each series being cast in a different foundry. The analyses are given in Table I. It is generally understood among founders that the specific strength of a cast bar in a given mixture diminishes as the diameter of the cast bar increases. The actual nature of the variation for three typical irons is shown in Fig. 1. While these curves are fixed by no more than three points, corresponding with the standard bar diameters used, there is no reason to suppose that the variation is otherwise than continuous over the range shown. If, then, the rupture modulus varies continuously over the range 2.25 in. to 0.8 in. in dia., that is, from *A* to *B* in Fig. 1*a*, then it must vary over an ordinary casting tolerance, say, from 1.3 in. to

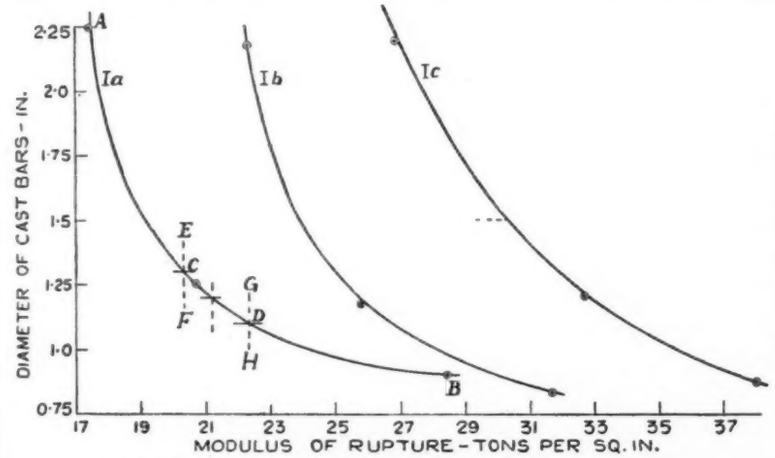

FIG. 1.—VARIATION OF RUPTURE MODULUS WITH DIAMETER.

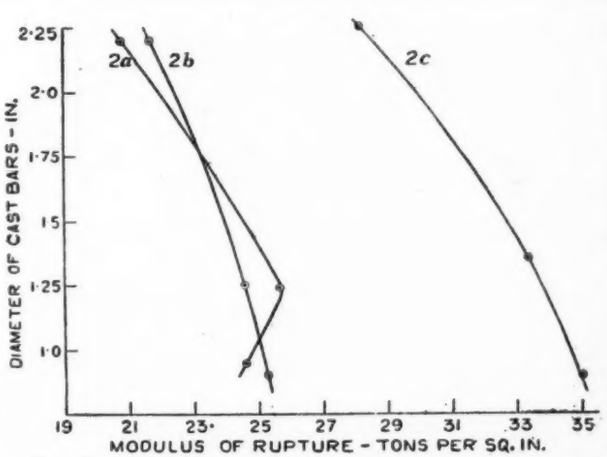

FIG. 2.—VARIATION OF RUPTURE MODULUS WITH DIAMETER.

* A Paper presented to the Autumn Meeting of the Iron and Steel Institute.

1.1 in., that is, from *C* to *D* in Fig. 1*a*, for a nominal 1.2 in. diameter bar. The ordinary conversion formulæ assumes that the modulus is constant over this range—*i.e.*, that it follows the line *EF* for oversize or *GH* for undersize bars, instead of *CD*. An undersize bar by conversion methods always gives better, and an oversize bar always gives worse, standard bar figures than should be the case. Not only is the present conversion method erroneous, but where the bending strength follows a curve such as *AB*, no simple conversion will enable the modulus for one diameter to be utilised for calculating that for another diameter. The magnitude of the error naturally depends upon the slope of the curve as well as upon the difference between cast and nominal sizes. In the case shown in Fig. 1*a* the oversize bar 1.3 in. in dia. has a modulus of 20.5 tons per sq. in., and the undersize 1.2-in. dia. bar a modulus of 22.3 tons per sq. in. The 1.2-in. bar has a modulus of 21.2 tons per sq. in.

Table I.—*Chemical Analyses of Bars.*

Bar Series.	Analysis. Total carbon. Per cent.	Silicon. Per cent.	Manganese. Per cent.	Sulphur. Per cent.	Phosphorus. Per cent.
1*a*	3.37	1.90	0.68	0.10	0.76
1*b*	3.42	1.55	0.55	0.08	0.49
1*c*	3.28	1.03	0.45	0.10	0.63
2*a*	Engineering iron of unknown composition				
2*b*					
2*c*	—	1.34	0.57	0.16	1.00
4*a*	3.13	2.64	0.43	0.09	1.18
4*b*	3.31	2.08	0.78	0.11	0.98
4*c*	3.08	2.07	0.37	0.15	1.04
5*a*	4.20	2.83	0.69	0.06	0.44
5*b*	3.26	2.91	0.41	0.06	1.23
5*c*	3.52	2.52	0.70	0.06	0.94
5*d*	3.33	2.78	0.62	0.07	1.10
5*e*	3.51	2.90	1.17	0.07	1.15
6*a*	3.86	1.13	0.90	0.05	0.16
6*b*	3.68	1.93	0.85	0.08	0.19
6*c*	3.27	1.81	1.10	0.05	1.14
6*d*	3.60	0.75	0.70	0.10	0.30
6*e*	2.73	2.41	0.71	0.10	0.19
8*a* & 8*b*	3.52	2.10	0.60	0.10	0.34
8*c*	3.35	2.15	0.65	0.07	0.47
8*d*	3.53	1.70	0.85	0.11	0.44
8*e*	3.29	1.10	0.95	0.06	0.11

It is therefore suggested that the true criterion of transverse strength is the modulus of rupture determined for the actual bar section, measured at the point of fracture. The lack of any simple conversion may appear to create difficulties, but no purpose is served by ignoring facts. It will be shown later that many advantages accrue from testing bars over a range of sizes rather than of one size, as this enables the characteristic curve to be determined over the range.

Change of Strength with Size.

The characteristic curve connecting strength with diameter, which, it may be noted, can also be obtained for tensile, compression, shear, and torsion as well as transverse tests, has been obtained for a variety of irons, the results of three of these being shown in Fig. 2, and the corresponding analyses in Table I. Sometimes the curve is concave upwards, as shown in Fig. 1, sometimes concave downwards, or straight with varying angles of slope, as shown in Fig. 2. These variations confirm ordinary founding experience, for, according to conditions of composition and rate of cooling, some irons have a core almost as strong as the outer envelope, while others, being highly graphitised irons with a ferritic centre, have a core of very low strength. In the latter, the strength falls away quickly as the diameter increases. The difficulty of predicting the character of the curve for any iron at this stage makes any mathematical treatment impossible. Endeavours have been made, for instance, to determine experimentally a factor which could be used for obtaining the strength of one size of bar from that of another size, but while this may serve for one mixture and melting régime, it would not necessarily hold for others.[2]

The bars fixing the points of any one curve in Figs. 1 and 2 were all poured at the same time from the same mixture, but, as will be seen from Table I, the mixtures differ from curve to curve. Naturally an iron intended for thin castings of high silicon and total carbon content will show low strength in a thick section compared, for example, with an iron intended for heavy, hard, engineering castings. Each is suitable in its particular application, and the advantage of a range of test-bar thicknesses for each type is referred to more fully below.

It has been suggested above that once the characteristic curve has been obtained the strength of any particular bar can be predicted by interpolation. Thus, in Fig. 1*c*, a bar 1.5 in. in diameter of the same material cast under the same conditions would have a rupture modulus of 30.3 tons per sq. in. Care, however, must be exercised in extrapolation. Up to date only a limited experience has been gained from very heavy bars, for which the span has to be increased to obtain an easily read deflection. It has also been found that in bars of the same material cast at the same time, the modulus of rupture increases and the deflection diminishes as the span diminishes. Similarly, the modulus diminishes and the deflection increases as the span increases. What the bar gains in flexibility it loses in rupture strength.

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(3) C. H. Adamson and G. S. Bell: "Transverse and Other Tests on Cast Iron Test-Bars," *Iron and Steel Institute, Carnegie Scholarship Memoirs*, 1927, vol. xvi. pp. 1-34.

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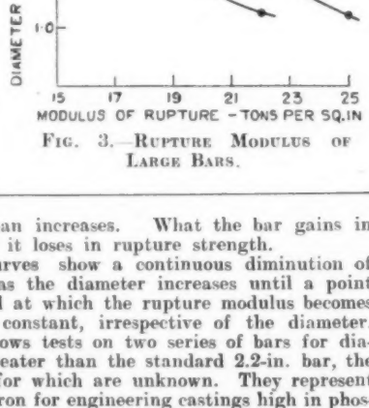


Fig. 3.—Rupture Modulus of Large Bars.

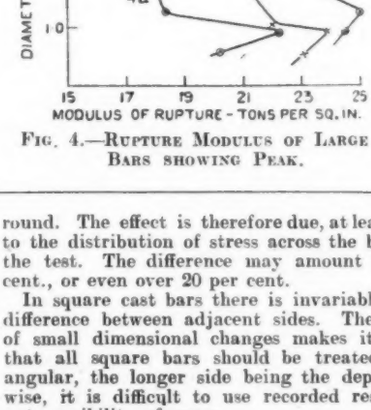


Fig. 4.—Rupture Modulus of Large Bars showing Peak.

The curves show a continuous diminution of strength as the diameter increases until a point is reached at which the rupture modulus becomes virtually constant, irrespective of the diameter. Fig. 3 shows tests on two series of bars for diameters greater than the standard 2.2-in. bar, the analyses for which are unknown. They represent common iron for engineering castings high in phosphorus. At the other extreme, as the section diminishes, the metal changes and begins to mottle, ultimately becoming white. The strength which has hitherto steadily increased now begins to diminish owing to the brittleness of the free carbide, and there is a sharp discontinuity in the curve shown, for example, in Fig. 2*a*, while Fig. 4 shows three series from the author's results, the analyses being given in Table I.

The necessity for a number of points in the neighbourhood of the peak in order to determine the peak will be obvious. The peak represents the highest strength which can be obtained from a given diameter and for a given composition and set of melting conditions. The metal at the thickness represented by this point is much too sensitive to chilling to be used in ordinary foundry work, but the more nearly this peak can be reached the stronger will be the metal. Laboratory control, of course, enables the point to be approached more closely than is otherwise possible. It will be seen that a given strength is obtained for two diameters, one on each side of the peak, but there would be a marked difference between the respective deflections.

Considerable care is required in moulding and casting sound thin test-bars, the minimum diameter called for in B.E.S.A. Specification 321, 1928, being 0.875 in. It will frequently be found that a low result on a thin bar is due to a defect in the bar, and not to the strength having passed its peak value. In order to ascertain whether the rectangular section would yield a similar characteristic, tests on rectangular bars were made from a series of some twenty casts, the bars for each cast being the ordinary 0.5-in. square bar at 12-in. centres, the Admiralty 1-in. square bar at 12-in. centres, and the B.E.S.A. 2 in. × 1 in. bar at 36-in. centres. Several of the curves, characteristic of the whole, are shown in Fig. 5, the areas of the bars being used as ordinates. The analyses appear in Table I.

It is found, as a matter of common experience, that square bars invariably give lower transverse results than round bars of similar size. It was uncertain whether this was a testing effect or a casting effect until some tests were made by Dr. A. L. Norbury in the laboratories of the Cast Iron Research Association. A group of round bars was cast, some being skin-machined and others being machined square before testing. From the same metal a group of square bars was cast, some being skin-machined and others machined round before testing. The results showed clearly that the round bar is stronger than the square bar, even when prepared from a bar originally cast square, and that the square bar is weaker than the round bar, even when prepared from a bar originally cast round. The effect is therefore due, at least in part, to the distribution of stress across the bar during the test. The difference may amount to 10 per cent., or even over 20 per cent.

In square cast bars there is invariably a slight difference between adjacent sides. The influence of small dimensional changes makes it desirable that all square bars should be treated as rectangular, the longer side being the depth; otherwise, it is difficult to use recorded results without possibility of error.

The figures for breaking load for transverse bars of both grades A and C of British Engineering Standards Specification 321, 1928,[1] were obtained in the main by direct experiment on large numbers of bars of all the standard sizes. The modulus of rupture determined from the specified breaking loads and diameter is shown plotted against diameter in Fig. 6, together with the curve for the grade B originally projected but as yet unspecified.

Current Methods of Treating Transverse Results.

The difficulties introduced by current methods of treating the transverse test can be illustrated by recent contributions to the study of cast iron. It would appear in some cases that the engineering formulæ utilised for converting the result on a cast size to the corresponding breaking load on a specialised size have been treated as having universal validity. Many tests have been made, leading

to the conclusion that the conversion formulæ do not hold for cast iron.

The formulæ, however, cannot be criticised as untrue or invalid because, by the circumstances of their development, they can only hold for conditions which are violated every time a transverse test is taken—that is, for perfectly elastic bars, or bars tested within their elastic limits and under such conditions that normal sections remain plane and the neutral axis passes through the centre of the section, that the elastic properties of the material remain the same in tension and in compression, and that stress is strictly proportional to strain.

The modulus of rupture on a cast-iron bar is not an absolute value even for bars of the same length and section. It is an index, however, of a particularly useful kind under standard testing conditions to the combined influences of constitution and rate of cooling on the mechanical strength—that is, now considered. Drawing the size-strength curves, the results are expressed in Fig 8, the analyses being given in Table I. The curves yield the following conclusions, which confirm the results given above:—

(1) Bars cast and tested square give lower specific transverse strengths than bars cast and tested round. Thus, curves 8*a* and 8*b* are for square and round bars for the same melt. Other square bar curves are excluded, and (2) a regular relationship exists between the rupture modulus and the diameter for bars of the same composition and method of casting. The curves for the four melts of round bars shown, 8*b*, 8*c*, 8*d*, 8*e*, are practically straight and almost parallel.

A progressive relationship is also shown between strength and composition (silicon content) for bars of the same diameter and melting conditions. This was foreshadowed in Fig. 1, and can now be considered.

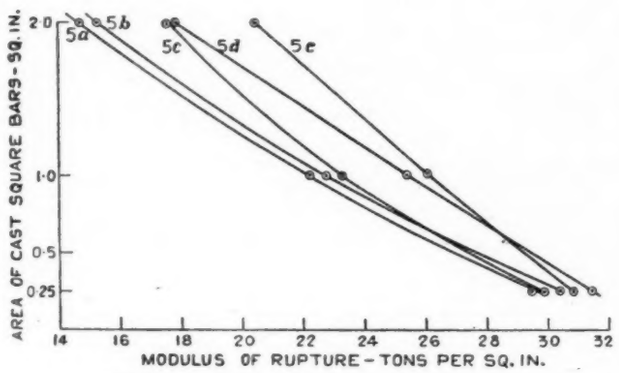


Fig. 5.—Rupture Moduli of Square Bars.

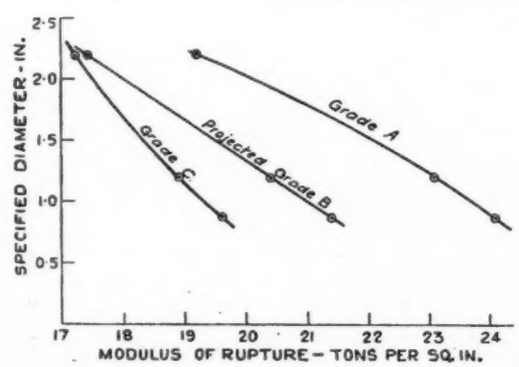


Fig. 6.—Rupture Moduli of Standard B.E.S.A. Bars Specification, 321, 1928.

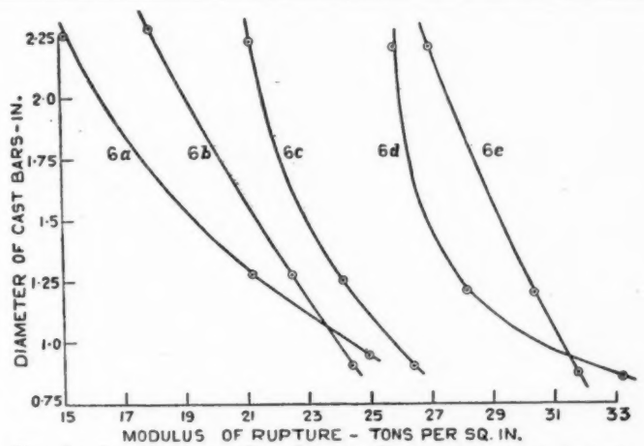


Fig. 7.—Size-Strength Curves from Data by Adamson & Bell.

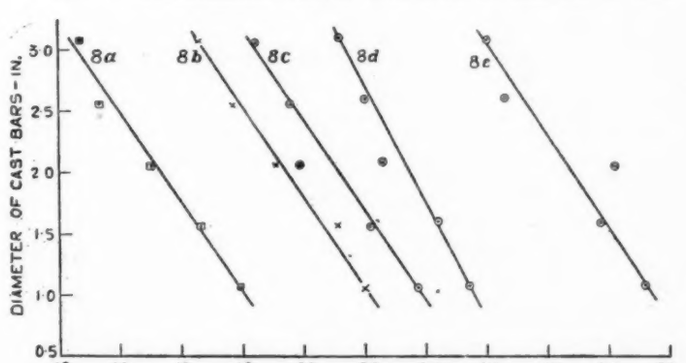


Fig. 8.—Size-Strength Curves from Data by Rother & Mazurie.

of chemical composition, pouring temperature, mould temperature and thickness.

A Paper by Adamson and Bell[3] provides a particularly valuable collection of data in connection with the transverse test, since the actual bar dimensions and breaking loads are given for a series of bars of at least three diameters and for a wide range of compositions. The author has obtained characteristic curves from five of the compositions recorded, the actual rupture modulus being plotted against the diameter. The results are shown in Fig. 7, the corresponding analyses being given for convenience in Table I.

A Paper by Rother and Mazurie[4] is also useful, inasmuch as it gives actual transverse results on bars of different compositions, shapes and sizes up to 3 in. in diameter, all poured in the same foundry. Treated in the same manner, this Paper yields definite conclusions which do much to dissipate the alleged mystery of cast iron and the capricious nature of its variations. Square and round bars in this series were cast from 1 in. to 3 in. across in five mixtures, four of which are

Relationship Between Strength and Composition.

The aim of much recent research is to establish a relationship between strength and composition of cast iron. If these can be shown to correlate even for a single set of melting conditions a great step forward in foundry control becomes possible. The transverse test has been chosen for this correlation in the present instance, not only because it is simple, cheap and rapid, but because, when expressed as rupture moduli, the results bear a general relationship to other tests. The experience of the British Cast Iron Research Association is that the transverse strength of a given iron is usually 1.8 to 2 times the tensile, which is usually one-fifth to one-fourth of the compression strength.

The number of elements in cast iron makes such a relationship particularly difficult to establish. They may vary from cast to cast, and it is unfortunately very difficult, under commercial melting conditions, to maintain compositions constant except for one deliberately varied element without having a wider range of pig-irons and a closer control of scrap than is usually necessary in ordinary practice. Strength, however, is predominantly influenced in a given section by the total carbon and silicon; in these experiments the total carbon was not maintained sufficiently constant to enable silicon alone to be used, and hence "T.C. +Si" is used as an index to composition, although "$\text{T.C.}+\frac{\text{Si}}{3}$" might be a preferable combination. The influence of other variables of composition is for the time being ignored, although the importance of phosphorus in this connection will be obvious. It may broadly be expected, however, that for similar raw materials and melting conditions, differences in strength in the same bar will be due to changes in composition; and for different melting conditions and similar compositions strength differences will be an index to changes in melting conditions. This correlation of strength and thickness for different sections is of particular importance to designers of engineering castings, who at present have little or no reliable information on this point, as it will lead to the more scientific disposition of material in cast-iron structures, and prevent the indiscriminate or promiscuous thickening of sections when an additional stress has to be met.

Fig. 9 shows curves connecting the total carbon plus silicon and the strength for bars of various thicknesses, derived from Fig. 8. They show a striking degree of consistency, indicating that for a given melting régime there is little scatter, in spite of the fact that two of the melts contained steel scrap.

An attempt to construct a similar curve from the results published, for example, by Adamson and Bell,[3] or from the results quoted by the present author, shows the degree of scatter which would be expected from marked variations of composition other than total carbon and silicon and from bars originating in a number of foundries. It is hoped at a later date to present results from

(*Continued on page 222.*)

D

Spalling of Furnace Bricks.

A bulletin on spalling, by MR. STUART M. PHELPS, issued by the American Refractories Institute, states that two major causes, in general, account for the destruction of refractories in furnaces. These conditions, which are so common, are more serious than all the other destructive forces combined. If spalling and slag action were not encountered, problems with refractories would be comparatively simple. Furthermore, they are most difficult to combat by reason of their obscure and complicated manner of occurrence. Their presence is always apparent, but the analysis and detailed explanation of how they proceed and how to prevent their action require careful consideration.

Studies conducted in recent years on these subjects have been most valuable. They have simplified problems materially, especially by way of offering explanations as to the operation of spalling action. The corrective measure for one type of spalling may not be suitable for the others. Often the cure may be furnace design or operation, while in another type the answer is a more suitable grade of brick.

Mechanical spalling (*i.e.*, that due to rapid heating of wet brick; abuse in removing clinker and slag; unequal and excessive stresses; pinching; want of mechanical strength and toughness) usually can be overcome or corrected with due attention to furnace design and operation. For example, bricks are often set in a wet condition and require considerable time to be thoroughly dried. If they are heated too rapidly while wet there is real danger in the formation of steam under pressure within the pores which will expand and weaken or crack the brick.

In some furnace operations there are areas of the brickwork upon which slag and clinker build up. Its removal is a difficult job at best, so that it often happens that considerable brickwork is unnecessarily removed. The only remedy for such a loss, after it is minimised by careful operation, is to use the strongest brick possible consistent with other properties that are required. A common cause of mechanical spalling is that called "pinching," caused by the pressure exerted when the bricks expand during heating. Refractories, like other materials, expand when heated. If the portions of the brick which are heated are not free to expand, a considerable pressure will build up. This pressure will readily break off the ends of brick to relieve the strain. It is sufficient to cause arches to rise and has been known to cause serious damage in large furnaces. When an arch expands, the increased pressure on the inner ends of the bricks often causes a few bricks, or even a layer, to be pinched off. In laying up an arch it is better to have the outer ends of the arch bricks fit close than the inner ends. Warped and untrue bricks are quite certain to spall, especially when laid up dry in an arch. This is not so apt to happen on imperfect bricks when a grout is used to take care of inequalities.

In sidewall construction a good plan is to insert in the joints at intervals the necessary thickness of cardboard, which will burn out leaving a space for expansion. The space necessary for the bricks to expand can be figured from their co-efficient of expansion. As a rule, bricks laid up with thick joints have more space to expand because most joint material has some shrinkage. Thin joints are desirable from the refractoriness and slag point of view, but should be used with precautions for the reasons mentioned above.

Structural Spalling.

Structural spalling (*i.e.*, that due to slags and fluxes; character of the material in joints; insulation of refractories; no provision for expansion; thin joints; vitrification shrinkage; nature of bond; structure; degree of firing; accuracy of shape; etc.) is a type of action which is not generally known or considered. Most refractory materials undergo a marked change in their structural or physical properties after prolonged use. After long exposures to high temperatures and slags or fluxes, the bricks invariably become vitrified to a certain degree. Accompanying this vitrification usually is a permanent change in the dimensions of the exposed portions. If the expansion or contraction, as it may be, is excessive, a tendency toward a separation between the original and heat-treated portions will be noted. The seriousness of this action depends upon a number of properties. The expansion or shrinkage may proceed to a considerable degree without any evidence of separation. A gradual transition from the altered to the unaltered portions will reduce the tendency toward cracking or separating while pronounced shrinkage of a given section is apt to cause the severing of the dissimilar portions.

Shrinkage is the main cause of structural spalling; therefore, conditions such as slagging or fluxing which may be present within the furnace will hasten the action. Unnecessarily high temperature in some operations results from the insulation of the walls, which is conducive to shrinkage or spalling. Open joints, caused by shrinkage or the melting away of unsatisfactory cement, are serious because they allow the heat to come in contact with a larger area of the brick, thereby heating the face to a greater depth and to a higher temperature.

Bricks that do not show marked tendencies toward shrinkage in a given furnace operation are naturally the most resistant to this spalling. Refractoriness is not necessarily the criterion for resistance, since diaspore bricks are apt to exhibit this type of failure. Constancy of volume, accompanied by refractoriness, is highly desirable, since the more refractory body will be less susceptible to action of fluxes, which accelerate shrinkage. Contrary to the usual belief, spalling may be reduced in certain cases by employing a harder-fired brick, which would reduce the shrinkage in service.

Thermal Spalling.

Thermal spalling (*i.e.*, that caused by the rapidity and range of thermal fluctuation; contamination by slags and fluxes; tightness of joints; previous vitrification; degree and uniformity of reversible thermal expansion; heat transfer; elasticity; plastic flow) is the type most commonly considered. In a number of kinds of refractories, for example, silica, chrome and magnesite, it is the all-important variety. It is the most difficult to prevent from the producer's point of view, since it is caused by certain properties of the bricks which are exceedingly difficult to alter. As previously mentioned, bricks expand when heated and likewise contract when cooled. A brick is a rigid body and in order to conform to the increased size of an expanded portion several conditions must be met. A brick having sufficient elasticity could not be spalled by any thermal shock. Clay bricks have been studied to ascertain the presence of properties making for elasticity, and it has been shown that they are elastic up to about 800 deg. C. and at higher temperatures they show a plastic flow. These properties, however, are present only to a small degree.

Another factor is that of the thermal conductivity of the brick. One having a high rate of heat flow would not allow as great a difference in temperature to exist between sections as one of lesser efficiency. Little can be done to materially increase the thermal spalling resistance of most bricks. Soft firing and an open structure help in certain kinds of service. A careful selection of raw materials is often an assistance and the blending of clays having approximately the same thermal expansion is favoured over those which show appreciable difference in their co-efficients. Open-burning clays are more desirable than those which readily vitrify, especially in the case of the plastic or bond clay. Coarse, splintery particles for grog are advantageous.

In some furnace operations the rate of heating or cooling of the lining is sufficient to cause excessive thermal spalling of silica, chrome and magnesite bricks. The high expansion of silica bricks at certain temperatures makes them sensitive to quick changes of temperature, and often this expansion can be altered in a measure by developing in them the desired physical forms of silica. The reversible expansion of most refractories cannot be altered in any way.

It is believed that the effects of rapid temperature changes upon clay refractories have been over-emphasised. The spalling which does occur results from other causes equally as important as that of thermal shock. The general problem is not a simple one with so many factors involved, and especially when they interact as they often do.

The Use and Interpretation of the Transverse Test for Cast Iron.

(*Continued from page* 221.)

a systematic examination of a range of compositions in British foundries.

Taking a mixture corresponding to curve 8*c*, Fig. 8, a bar 1 in. in diameter has a rupture strength of 23.9 tons per sq. in., and hence would carry 18.75 tons. A bar 2 in. in diameter has a rupture stress of 21.2 tons per sq. in., and hence would carry 66.6 tons. Hence, when the area is quadrupled, the load-bearing capacity is raised about 3.5 times. An iron with a characteristic similar to that shown in Fig. 1*a* under similar conditions has its load-bearing capacity increased less than three times.

By the phrase "melting régime" is meant that particular set of operating conditions which obtain at a given time in a particular foundry, or at least for one cupola of that foundry. These conditions may vary slightly with alterations in raw materials such as coke, or with changes in personnel and supervision which involve changes in practice, but for practical purposes they may be taken as constant. If for one such régime a series of bars be cast in one usual mixture in a wide range of diameters, and if this be repeated for the whole of the mixtures normally employed, a diagram could be prepared similar to Fig. 9, which would give the transverse strength of a bar of any diameter within the range of compositions used. Such a diagram would act as a base for the foundry. It could also be used to determine compositions required to give a particular transverse strength, and hence a particular tensile strength. With such a base it would then be possible systematically to ascertain the effect on strength of such operating changes as variations in cupola melting conditions; variations in charges without alteration of ultimate composition by the use of hot and cold blast irons, steel and scrap; variation in charges giving ranges of manganese, phosphorus, sulphur and special elements; and variations in moulding practice.

Finally, by direct experiment, the strength of standard bars could be compared with similar sections cut from actual castings.

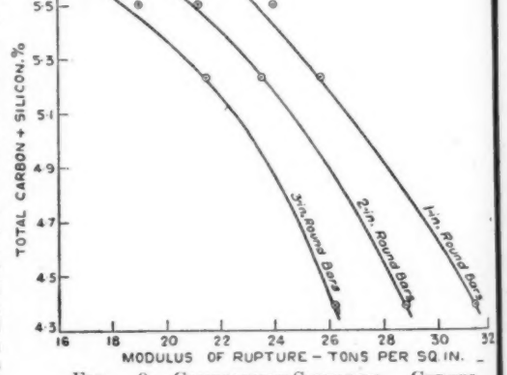


FIG. 9.—COMPOSITION-STRENGTH CURVES FROM DATA BY ROTHER & MAZURIE.

The Theory of Cast Iron.

By Arthur B. Everest, Ph.D.

Several contributions to the literature on cast iron have been made under the above general title in the recent past. Many of these contributions, however, are so detailed in their theory that they leave the practical man gasping for breath among a profusion of complicated diagrams and lengthy technical terms far removed from the everyday life and atmosphere of the foundry.

Unhappily, this state of affairs is quite unavoidable, because the cast iron of commerce is in detail so complicated, that any theory endeavouring to explain its structure must be founded on a mass of information taking into consideration all possible variables in the influences controlling the structure of the casting. As is well known, the number of these variables is large—including as it must, all the elements present in the iron as impurities or intentional additions, as well as casting conditions.

To-day we see the first steps in the gathering of the detailed information concerning the influence of some of these variables being completed; but it is a slow task, and it will be a very long time before the behaviour of even an ordinary cast iron will be completely understood. However, as information comes to hand on various sections of the problem—on the influence of various elements on cast iron, and on the control of the structure by various thermal processes, we are attaining to a broader understanding of some of the outstanding features of the everyday alloys, and certain definite principles are becoming more and more clearly established.

Cast iron is by nature and definition essentially an alloy of iron and carbon as base, with other elements as impurities, the most important of which is silicon; consequently it is clearly the natural course to turn to the pure alloys in commencing the study of the product of the iron-foundry. Many wordy battles have been waged around this very point in the recent past: but the fact remains that our theories, metallurgical technology and even nomenclature must have some sound and definite foundation, and where else in the field of cast iron is this starting point to be found except in the study of the simpler pure alloys, as has repeatedly been emphasised? Can those who decry such study as being too far removed from the cast iron of practice seriously suggest, having in mind the enormous complexity of the problem, any surer or better basis for our study. Perhaps it is that they do not appreciate that the theorist is truly endeavouring to build himself a sure and safe foundation on which subsequently he will erect a complete structure of theory, which ultimately will adequately explain all the tricks and variations of the commercial product. This must be his ultimate goal, though even he cannot yet picture the structure in all its aspects. But meanwhile let not his critics mistake the foundation for the completed whole.

DR. EVEREST, the author of this Paper, has had practical experience in the Works of the British Thomson-Houston Company, at Rugby. After graduating at Birmingham University he obtained a Research Scholarship awarded by the British Electrical and Allied Manufacturers' Association, and the degree of Ph.D. was granted on the results of an extensive research on the influence of Aluminium on Cast Iron, conducted with the guidance of Professor T. Turner and in collaboration with the British Cast Iron Research Association. He is now engaged on a research on Nickel in Cast Iron, under the direction of Professor D. Hanson and with the assistance of local manufacturers, and of the British Cast Iron Research Association. He is a member of the leading Metallurgical Societies, including the Institute of British Foundrymen.

But at once we come up against a difficulty; in pure iron-carbon alloys, containing up to 4 or 5 per cent. of carbon we find a series of alloys which under all conditions, as far as our present knowledge extends, contains none of its carbon in the graphitic form; this, it will at once be appreciated, renders these alloys of a very different nature from the grey cast irons we are endeavouring to study.

In the former alloys the carbon is all present as iron carbide, and in the latter the major part is usually present as free graphitic carbon. This dual form of the carbon at once renders the study of the problem very difficult, but at the same time it can be stated quite definitely that it is to this same fact that cast iron owes its variety of properties and possibilities of development.

The complexity of the problem is further emphasised by the fact that whereas when a system embracing two elements has been investigated, the results may be represented for explanation by a plane diagram in two dimensions connecting the composition of the alloys with their structures at various temperatures; when a third element is introduced making a ternary system, our diagram is now become a solid, requiring a third dimension for its expression. But what of a system of 5 or 6 elements at least, as in the case of our cast iron? Ordinary geometry fails entirely to provide us with the dimensions required for the complete expression of the system in one diagram, so complicated has it now become.

Further study of the iron carbon system, however, has shown that the mechanism of the formation of the structure of the iron-graphite system when the latter is developed as the result of the influence of other elements present in the iron, is very similar to that of the iron-iron carbide alloys (of which the pure iron-carbon alloys are now known to consist). This simplifies the problem somewhat by providing us with corresponding forms of carbide and graphite, representing the various stages of structure formation in the alloy. It is accordingly of interest to consider briefly the various forms of carbide and graphite which may occur in the pure alloys, and in commercial irons, in which circumstances permit of the existence of these forms.

Forms of Iron Carbide.

A study of the usual iron-iron carbide diagram (Fig. 1) reveals the fact that four forms of the carbide (called cementite) may exist in the cooled casting. These four forms are listed, and illustrated as follows:—

In alloys containing over 4.3 per cent. of carbon the first constituent to solidify from the

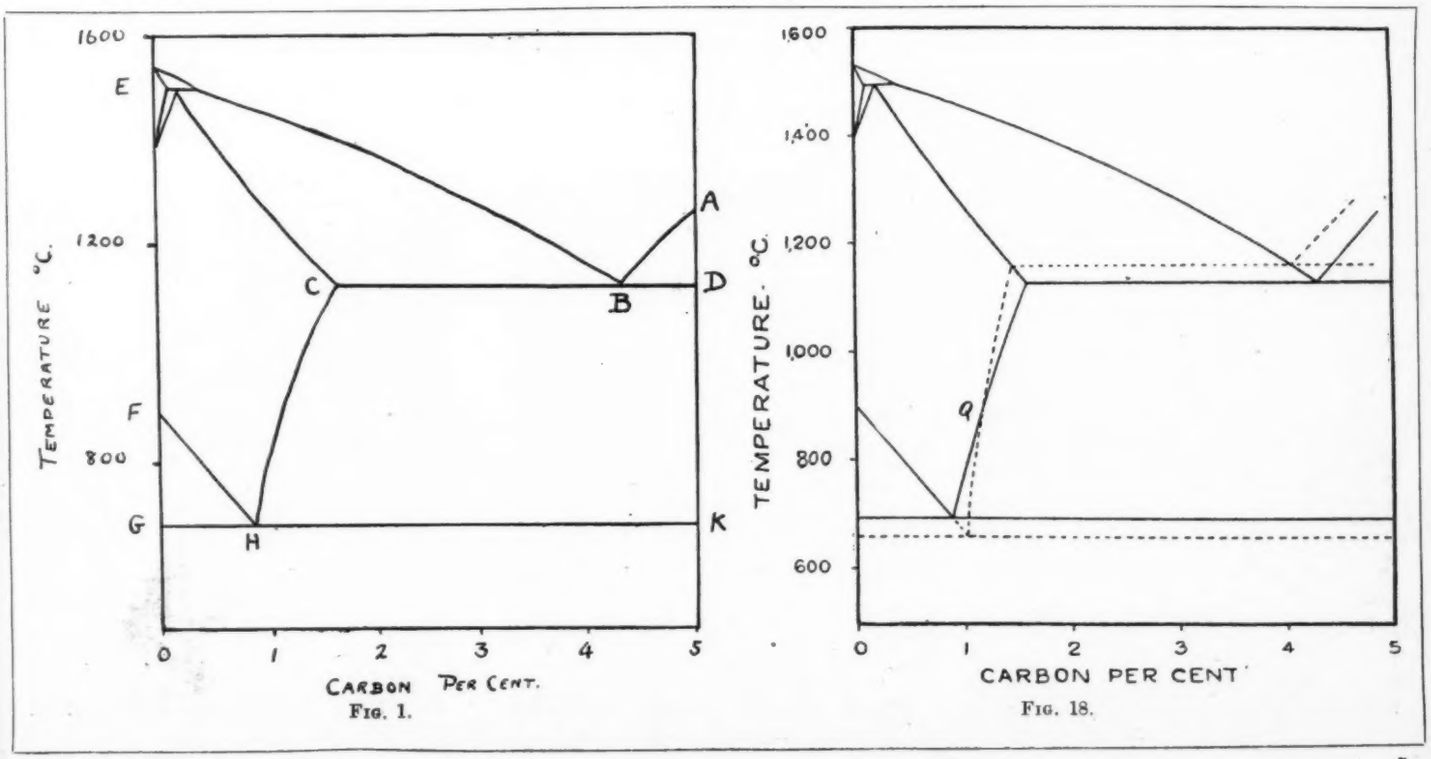


FIG. 1. FIG. 18.

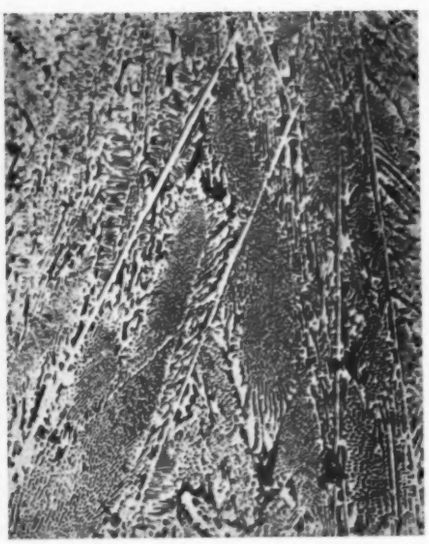


Fig. 2.—× 100.

Fig. 3.—× 500.

Fig. 4.—× 8.

molten iron is pure cementite—the "pro-eutectic" cementite which separates as indicated by line AB in Fig. 1. This solidifies as long needle crystals, illustrated in Fig. 2. This form of carbide is of little practical importance since it should only occur, as will be emphasised later, in pure iron carbon alloys containing over 4.3 per cent. of carbon—a condition which never pertains in ordinary foundry practice. However, this form of carbide may be found in the pure alloys containing less than 4 per cent. of carbon cast under conditions which induce segregation, for these alloys are frequently liable to this phenomenon. In fact, Fig. 2 is of the centre part of a bar cast ½ in. square in green sand, from a washed iron containing only 3.7 per cent. of carbon, yet the condition of cooling has been such that the carbon content in the centre of the bar, is as shown by its structure, over the eutectic concentration of 4.3 per cent.

The second form of carbide is that occurring in the austenite-cementite eutectic (sometimes called Ledburite) which is formed according to the constant temperature line CD in Fig. 1. This constituent, which is illustrated in Fig. 3 is often found in ordinary white irons and in the chilled parts of grey castings, it is also illustrated, as the matrix of the structure in Fig. 2.

In alloys containing amounts of carbon lower than that represented by point B, the first crystals formed from the liquid melt, on solidification, are of the austenite constituent. This is a solid solution of the carbon in pure iron, which latter at these temperatures is in the gamma modification. These crystals constitute the beautiful dendritic or fir-tree-like crystals which are often seen suspended in cavities in castings which have been formed by the drawing away of liquid metal after solidification has commenced. These crystals in a typical "draw" in a large casting of unsuitable design are illustrated in Fig. 4. They are also found in sections of white iron, embedded in the austenite-cementite eutectic Fig. 5.

The carbon content of these crystals during the first stages of cooling is indicated by the line EC, and it is seen from the disposition of lines EB and EC, and from a consideration of the phase rule, that these primary austenite crystals are in the first place cored with respect to carbon, that is to say that the carbon content in the aggregates increases from the centre towards the edge of the crystal, this variation in carbon being accompanied by a corresponding variation in the properties of the metal. Evidence of coring is seen in cast irons which are maintained austenitic by the use of suitable alloy additions (Fig. 6), and further evidence of this phenomenon will be given later. In normal commercial irons, however, no evidence of this is normally seen, owing to the fact that carbon under these conditions is so mobile that apparently even during the short time which elapses during this primary crystallisation, the carbon content of the grains equalises itself by diffusion from the outside towards the centre of the crystal, and by the time the temperature of the mass has fallen as low as about 1,120 deg. C., which is the temperature of the eutectic separation indicated by line CD, the carbon content of these crystals is uniform and approaching that indicated by point C. 1.8 per cent. of carbon in the pure alloys. At this temperature the remainder of the melt has composition B, and solidifies at constant temperature as the austenite cementite eutectic described above.

During the fall of temperature between 1,120 deg. C. and 690 deg. C., corresponding to the levels of CD and GK in Fig. 1, the solubility of carbon in the primary austenite crystals falls, as shown by the decreasing carbon value along line CH. The excess carbon is precipitated in the austenite crystals, just as salt is thrown out of a cooling saturated solution. This gives us the third form of carbide, known generally as the pro-eutectoid cementite. It may occur in an acicular, or needle-like, form, or in a granular condition; the first form (Fig. 7) is found in the purer iron-carbon-silicon alloys, and also in the presence of some special elements, as, for example, in some nickel cast irons.

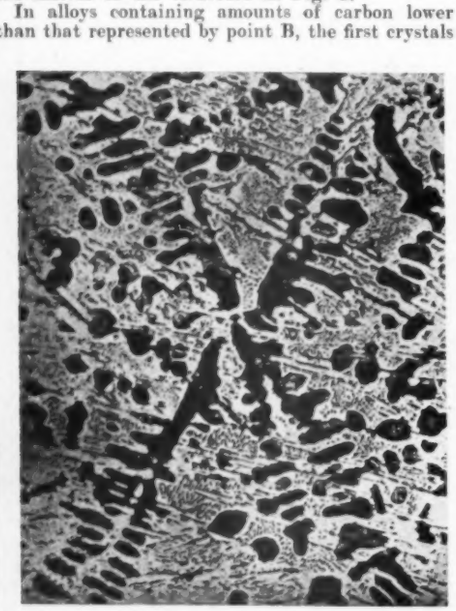


Fig. 5.—× 50.

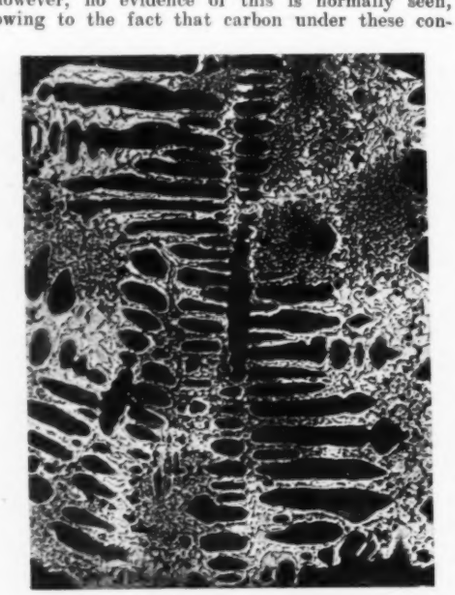


Fig. 6.—× 100.

Fig. 7.—× 500.

Fig. 8.—× 2,000.

Fig. 9.—× 500.

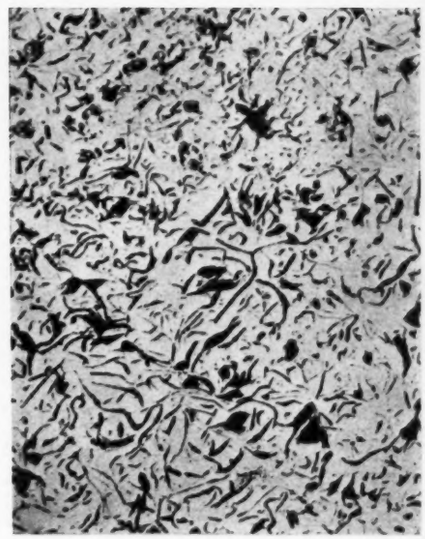


Fig. 10.—× 50.

The separation of this form of carbide continues until the concentration of the austenite has reached the point H at a temperature of about 690 deg. C. At this temperature the remaining austenite solid solution breaks down into its component parts—iron (now in the alpha form) and iron carbide, these being generally arranged in the well-known laminated structure, normally associated with pearlite (Fig. 8). Just in passing it might be mentioned that in pearlitic irons which have cooled under certain conditions the pearlitic form is seen to be very fine in the centres of the primary austenite grains, and is coarser towards their boundaries, as shown in Fig. 9. In this case the concentration of carbide is probably greater towards the grain boundaries, where the structure is more open, and this, it seems reasonable to suggest, is due to the "coring" of the original austenite, as mentioned above.

The carbide plates in the pearlite give the fourth form in which the iron carbide or cementite may occur. Under certain conditions the pearlite may assume a very fine lamellar or even a sorbitic form in which the carbide particles are granular rather than lamellar, but this is the case only in special alloyed irons, or in normal irons subjected to very rapid cooling conditions, as, for example, in very thin sections of a casting.

Forms of Graphite.

According to modern theory the theoretical iron-graphite system which must in part at least be considered as the constitutional basis of commercial irons, has a form very similar to that of the iron—iron-carbide system, according to which the above forms of carbide are produced; there is ample justification for this statement in Dr Hanson's recent theory, and the idea has been mooted from time to time in the production of the various "double" diagrams. Accordingly it is reasonable to assume that in irons where the cooling conditions favour the formation of graphite rather than of cementite, then four forms of graphite may be developed corresponding to the forms of cementite set out above. There is strong evidence in support of this, but it is a little more difficult to illustrate since even in the solid material the carbon precipitated in various stages is so mobile that rather than remain as a newly precipitated form finely divided it tends to migrate and grow into graphite forms already existing in the iron. A moment's thought about "malleable" structures will reveal the justification of this statement.

In putting forward illustrations of the various forms of graphite, the author realises that he is entering on a somewhat controversial subject, but feels that the following remarks, while in accord with modern theory, will fit in with the experiences of many workers both at home and abroad. For the moment reference will be made again to Fig. 1, the part of the diagram included by points ABCD and H being considered. As already mentioned, the forms of this part of the graphite diagram is similar to that of the carbide diagram, although the actual positions of the lines may be different in the two cases.

In thicker sections of castings made in soft iron a coarse graphite form is found in which the flakes are arranged in the rosette or whorl form illustrated in Fig. 10. There is no doubt that this form of graphite begins to grow in the upper temperature ranges, and represents graphite development along line AB. This applies to the coarse graphite seen in any ordinary casting.

The second form of graphite is that seen in the austenite-graphite eutectic, and is illustrated in Fig. 11. This form is found in many special cast irons, and even in ordinary cast irons under certain cooling conditions, but normally is not seen probably on account of the mobility of the carbon as mentioned above. There is a great deal of controversy with regard to the existence of this eutectic, some asserting that it is merely a decomposition product of the first formed austenite-cementite eutectic. Up to the present, theory has not had much to say with regard to these graphite forms. Professor Hanson's work clearly indicates the formation of the pro-eutectic, and

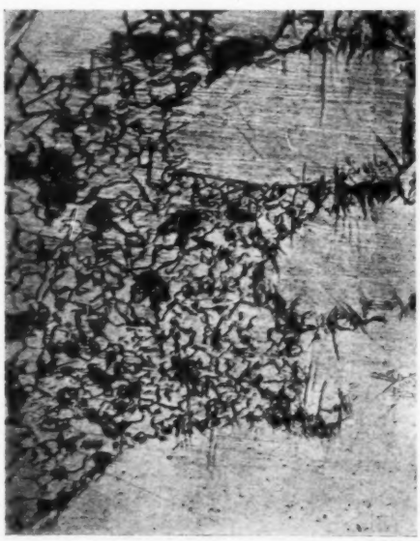


Fig. 11.—× 500.

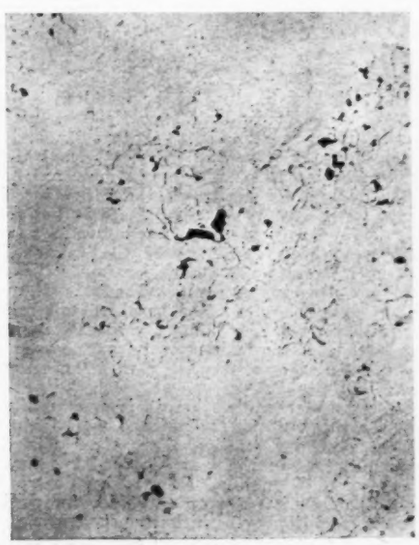


Fig. 12.—× 50.

Fig. 13.—× 100.

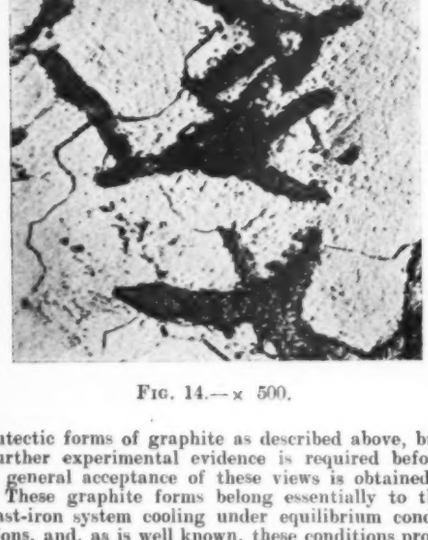


Fig. 14.—× 500.

eutectic forms of graphite as described above, but further experimental evidence is required before a general acceptance of these views is obtained.

These graphite forms belong essentially to the cast-iron system cooling under equilibrium conditions, and, as is well known, these conditions probably never hold in practice; and, as has already been pointed out by the author (Iron and Steel Inst., 1927, II, p. 176), the tendency under ordinary conditions of cooling is for the structure of the iron to develop along the lines of the metastable diagram; which implies the development of the austenite-cementite structure, rather than of the equilibrium austenite-graphite eutectic. Moreover, it is logical to expect that greater cooling rates will, from the shape of the diagrams developed by Dr. Hanson, favour the development of the metastable forms. This accords with practice in that in irons of certain ranges of composition, the greater cooling rates, obtaining in the thinner sections of castings, tend to produce a hard, white iron structure, containing excess carbides.

The third form of graphite, the pro-eutectoid graphite, is deposited inside the saturated primary austenite crystals as cooling proceeds, along line CH. This form of graphite, as shown in Fig. 12, may easily be the only form of graphite seen in a micro section of a piece of cast iron. For if composition and cooling conditions are such as to produce a mottled structure, then the form of graphite seen associated with the pearlitic structure of the grey spots is this third form. In such an iron the conditions of primary crystallisation in the castings have been such as to produce a structure according to the metastable system, due to the initial under-cooling of the melt; this accounts for the suppression of the first two forms of graphite, subsequent cooling, however, being slower, has permitted the development of this third form, as the solubility of carbon in the austenite gradually decreases as temperature falls.

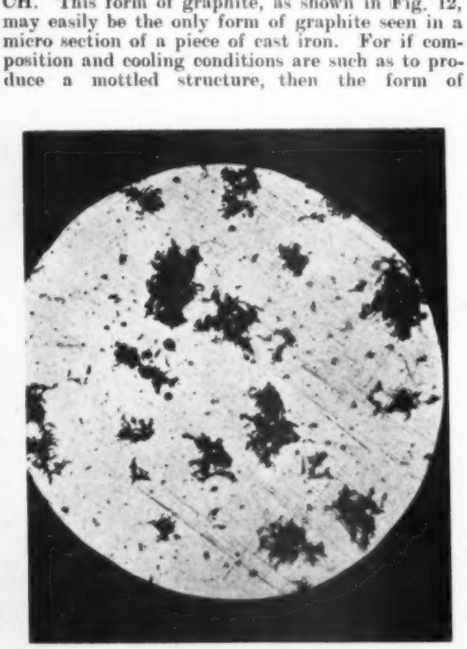


Fig. 15.—× 50.

The fourth form of graphite assumes very different configurations according to the conditions under which it is produced. In a very soft iron all four forms of graphite probably amalgamate, the three latter forms all growing on to the initial coarse flakes produced at the moment of solidification, or even, according to some workers, before the iron as a whole commences to solidify. Thus in a heavy section cast in a soft iron all the graphite will be in the form of coarse flakes. If, on the other hand, a pearlitic iron be heated at temperatures between 650 and 750 deg. C. for a sufficiently long time, the carbide constituent of the pearlite will break down, gradually giving ferrite and graphite. This graphite again will migrate, and will grow on to existing flakes. This process is illustrated in Fig. 13, which shows perlite and excess carbides breaking down under the influence of heat. This specimen had been annealed at 750 deg. C. for half an hour. Annealing for two hours caused decomposition to become complete, and a structure of final equilibrium consisting of ferrite and coarse graphite knots was seen (Fig. 14).

If graphitisation in a hard iron is inhibited by controlling its composition and cooling rate, giving a white casting suitable for malleabilising, then in the annealing process usually given to the castings in the blackheart process, all the carbides are decomposed, and, given that the conditions of annealing have been properly controlled, the resulting graphite is segregated in small nodules (Fig. 15), which are seen themselves to consist of very fine particles of graphite (Fig. 16).

We have seen, therefore, that in the solidification and cooling of the iron-carbon alloys four successive forms of carbide are developed, and there is evidence to show that these forms have their counterpart in the forms of graphite developed under the conditions which cause the alloy to solidify and cool according to the iron-graphite system. In cast irons various forms of carbide and graphite exist, either separately or together, and it is clearly the function of any theory of cast iron to define the conditions which govern the formation of one or the other structure in a given casting. The theory must be constructed so as to explain already established facts. Bearing this latter point in mind, we have developed the following very general theory to act as a guide in the construction of a more complete explanation of the structure of cast iron:—

A General Theory.

The ultimate structure of the cast iron is determined primarily by only two factors, namely, (1) the relative stability of the carbide and the graphite in the iron, and (2) the thermal history of the sample of iron under consideration.

Clearly under heading (2) the rate of cooling of the sample from the molten state is considered, this having as important an influence as any subsequent heat treatment of the casting, but for the moment we will consider factor No. 1.

It has already been pointed out in the consideration of the forms of graphite and carbide above that under the influence of heat, iron carbide will break down in a cast iron, to iron and graphite, or, expressing this chemically, $Fe_3C \rightarrow 3Fe + C$.

As a first approximation it is very useful to consider this reaction as perhaps underlying the structure of our casting. For, given a certain carbon content in the iron, we all know that by excess or deficiency of other elements we can make the iron hard or soft at will, for a given set of conditions of thickness of casting and so on. We know also that in almost all castings carbide in some form is found as well as graphite, indicating that the above reaction may be considered to have proceeded to a certain extent, but not to completion. In other words, for a given composition of iron, under fixed conditions of melting, casting and cooling, a balance will be set up between the quantity of carbide and the quantity of graphite present; and this balance is determined by the relative stability of carbide and graphite.

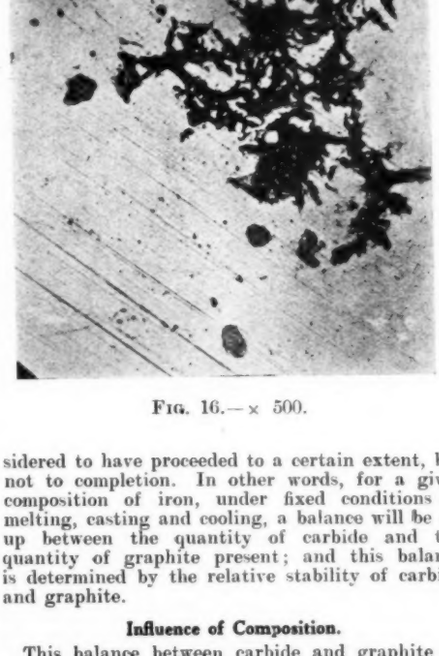
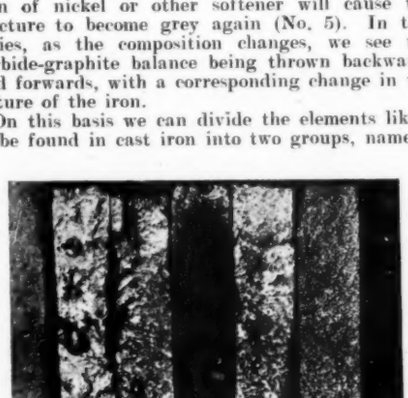


Fig. 16.—× 500.

Influence of Composition.

This balance between carbide and graphite is, in cast iron, determined by the presence of other elements as impurities or intentional additions as well as by the actual percentage of carbon present, and, moreover, it is very sensitive to slight changes in the composition of the iron. For example, reference may be made to Fig. 17, in which are illustrated fractures of castings, made under standard conditions, and similar in all respects except for the variation in composition. Fracture No. 1 shows the original white iron, and No. 2 the same rendered sound by the presence of 0.5 per cent. of silicon; No. 3 shows the same iron rendered grey, except at the extreme edge, by the presence of 1.2 per cent. of silicon. Now if we add 1.2 per cent. of phosphorus to our synthetic mixture, or a suitable quantity of chromium, the fracture is again rendered white (No. 4). To continue the experiment, a suitable further addition of nickel or other softener will cause the fracture to become grey again (No. 5). In this series, as the composition changes, we see the carbide-graphite balance being thrown backwards and forwards, with a corresponding change in the nature of the iron.

On this basis we can divide the elements likely to be found in cast iron into two groups, namely,



1 2 3 4 5

Fig. 17.—Fractions of Similar Castings made under Standard, with Composition varying.

those which favour carbide formation, like sulphur, chromium, and manganese and phosphorus under certain circumstances, these being some of the "hardening" elements; or those which favour graphite formation, most common of which are silicon and nickel, and also aluminium, all known to act as softeners. We can thus consider composition as determining the structure of the cast iron provided that no new micro constituent other than carbide or graphite becomes predominant on the addition of any special element. With silicon, for example, in a normal low-silicon iron, the carbide is relatively the more stable phase, but on the addition of more silicon the carbide becomes less stable, and graphite is formed, provided the cooling rate is not excessively high. Under these conditions the iron becomes grey.

As a general rule the elements which appear ultimately in solid solution in the iron are those which function as softeners, while the other group contains those metals which tend to form double carbides with the iron. In this connection the non-metals, sulphur and phosphorus, must be considered separately. The former of these having a powerful stabilising influence on the carbide, as seen, for example, in the whiteheart malleabilising process, where the relatively high sulphur content of the iron prevents decomposition of the carbide even after long annealing.

It must be emphasised that these remarks are intended to be only general in order to assist us in grasping the underlying principles of structure formation. No endeavour is made to take such side reactions as the formation of manganese sulphide into consideration, and phosphorus, present as a eutectic, must for the moment be ignored.

Having seen then that the condition of the iron in a given casting is determined by the chemical composition of the iron, we will now give some consideration to factor (2), which treats with the influence of thermal conditions on the casting.

Influence of Thermal History.

It is a matter of everyday knowledge that although a given composition of iron will produce good grey castings of medium section, this same iron may be quite unsuitable for thin section castings, since these will probably turn out white in fracture. In this we see the second underlying principle in the structure of cast iron, that the balance of carbide to graphite depends in general on the cooling rate of the casting for any specified composition of metal. Everyday experience of this is seen in the use of chills, to render the chilled surface of the casting hard by retaining a high carbide to graphite ratio, resulting from accelerated cooling; and again in the development of chilled or hard spots at corners of castings, or at a damp spot in the mould.

We can express the above in a general way by saying that accelerated cooling tends to favour the retention of carbide at the expense of graphite formation, and conversely, slow cooling favours the maximum development of graphite. It will readily be seen that on this depends the success of the production of such special irons as Perlit, etc.

The same principle holds for the after-heat treatment of the casting. Normally annealing at temperatures below about 650 deg. C. will produce little or no constitutional change in the iron, but annealing above this temperature will generally favour the development of the maximum quantity of graphite, by a gradual decomposition of further carbide. This is undoubtedly the first stage in the growth of cast irons in which the carbides, especially the pearlite carbide, not being stable, gradually decompose; this may take place to some extent at temperatures well below 650 deg. C.

Once again we must emphasise the fact that the chemical equation to which frequent reference has been made is given merely to convey an idea, and is not supposed to represent a universal reaction actually occurring in the iron. It can be stated, however, that when separation of any form is about to occur, the carbon is in a molecular condition, in which it will separate as carbide or graphite according to the controlling circumstances.

Experience teaches us also that where conditions favour the formation of graphite, the tendency is for the maximum graphite formation to be obtained in the higher temperature regions of structure formation, rather than in the lower. It is for this reason that the transformation occurring at the lowest temperature, namely, that represented by line GK, in most engineering irons, results in the formation of the carbide-bearing pearlite, and this appears from practice to be the most stable form of carbide. Irons of very varying ranges of composition, cast into widely different sections may all be "pearlitic" showing a combined carbon of 0.6 per cent. or slightly higher, providing strong evidence of the greater stability of this form of carbide over the other three forms.

A Particular Theory.

It is hoped that the above general remarks will meet with approval as a fair statement of the normal experiences of foundrymen in connection with their cast iron. An endeavour will now be made to show very briefly how these ideas fit in with one of the most recent theories, namely, that of Professor Hanson, put forward at the Iron and Steel Institute Autumn meeting, 1927.

At this point the author would like to express his most sincere thanks to Professor Hanson for permission to reproduce the diagrams herewith, and for much assistance and helpful advice in connection with his general work on cast iron.

As a result of extensive experiments Professor Hanson found that the structures obtained in pure iron-carbon-silicon could be explained by means of the phase rule when it was applied to a particular form of the so-called double diagram; and the exact agreement between the theoretical diagram and that obtained in his experiments is the basis of the Professor's theory. The double diagram, that is a diagram showing the constitution of cast iron taking into consideration both forms in which carbon can exist, namely, as iron carbide, and as graphite, has been put forward from time to time, showing one or other of the two forms as the stable and metastaple phases respectively, but never with any degree of conviction, or with any weight of experimental evidence. The essential point of Professor Hanson's double diagram is that in order to explain the structures obtained in cast iron, he finds that the lines of the two systems must cross, giving graphite as the stable phase at higher temperatures and carbide at the lower temperatures within certain ranges of composition; the crossing takes place at a point called for convenience Q, which for silicon contents of less than about two per cent. falls somewhere along the length of line CH in Fig. 1. The form of constitutional diagram in this case is as shown in Fig. 18, in which the graphite lines are shown dotted. The theoretic phase field diagram developed from this, together with the diagrams obtained experimentally, are all given in Professor Hanson's original Paper, to which reference should be made for further study.

In investigating alloys with various silicon contents Professor Hanson found that point Q tended to move up or down the diagram as the alloys tended to become harder or softer, thus in low silicon alloys point Q was nearer to C (Fig. 1), and in high silicon alloys, near to H. It will also be apparent from a study of Fig. 18 that when Q is nearer C, than in the upper ranges of the diagram the carbide lines are close to the graphite lines, and when Q is nearer H the lines are more widely separated. Again, the production of a metastable form is clearly dependent on the proximity of the lines representing the stable and metastable separations. Accordingly it would appear reasonable to say that the position of point Q in the diagram is a measure of the relative stability of graphite and carbide, to which extensive reference has been made above. As point Q moves down the diagram towards the eutectoid point (H), so graphite becomes progressively the more stable form and the iron will show less tendency to chilling.

Of course, it must be remembered throughout that Professor Hanson's diagrams refer to conditions of stable equilibrium, conditions which are by no means approached in commercial iron practice. However, reference to them in the above connection is justifiable, since they represent a state of affairs towards which the commercial iron is tending.

In the light of the above remarks then it will be clear that change in composition of the iron will result in general in movement of Professor Hanson's point Q, which in turn is an index of the relative stability of graphite and carbide; the nearer point Q is to C, then the more stable is the carbide form and under given casting conditions, the harder will be the iron.

Commercial irons, while not conforming to the stable equilibrium diagram when cast, will, nevertheless, conform to a metastable diagram, obtained by moving the position of point Q in the direction of C on the stable diagram. This metastable diagram will then represent the particular cooling conditions of the irons in question, which in turn will show the structures indicated by this metastable diagram.

We thus see that the particular theory examined is based on accurate scientific experiments, and gives precise evidence for a system of diagrams on which this theory has been established. The theory accords well with the observed facts connected with commercial cast iron, thus proving its own justification, and as Professor Hanson himself has shown, it is applicable not only to ordinary cast irons, but also to the special irons in evidence at the present time, and to the other phases of cast-iron metallurgy, such, for example, as malleabilising and the casting of chill rolls.

A Plea for Academic Research.

Extensive criticism has been levelled recently at research on the laboratory scale, and once more the author would like to refer to this matter; for surely in this theory which we have just considered we have an example of the birth and growth of theory from such much-maligned small-scale beginnings, and yet the more the theory is considered the more accurately is it seen to link up with practical metallurgy. The effects and comprehension of such a theory are very far reaching, and it may be years before we can understand fully the value of Professor Hanson's work, but, as far as we see it to-day, surely no one can suggest that the work has not been worth while, and it seems more than likely that in the time to come this will prove a most adequate foundation-stone for further theory as it becomes evolved.

Ceramic Society's Meeting at Glasgow.

The Refractory Materials Section of the Ceramic Society held its autumn meeting on September 13 and 14 at the Royal Technical College, Glasgow. The deputy President, MR. H. J. C. JOHNSTON, presided. There was an unusually full programme, although Mr. Dale's Paper ("Aluminous Refractories and Their Industrial Significance") was unavoidably postponed.

On the afternoon of the 14th a trip by steamer down the Clyde enabled members to view from the water the docks and shipbuilding yards of Glasgow. The next afternoon was taken up by a visit to the well-equipped Atlas Brick Works of the United Collieries, Limited, at Armadale, where firebricks and other refractories are produced on a large scale.

The following Papers were contributed in the order given:—(1) "Refractory Formers for Electric Heating Elements: Some Problems in the Manufacture and Use," by P. Cooper. (2) "Notes on Refractories for Salt Glaze Kilns," by W. Emery and A. Johnson. (3) "The Functions of Regenerators in Relation to the Refractories of Construction," by A. T. Green, F.Inst.P., A.M.I.Chem.E. (4) "Jointing Cements," by Cyril Edwards (Research Section, The Woodall-Duckham Companies). (5) "A Comparison of the Properties and Industrial Durability of the Lime-Bonded and Clay-Bonded Silica Bricks," by W. J. Rees, B.Sc., F.I.C., and W. Hugill, M.Met. (6) "The Dissociation of Carbon Monoxide in Contact with Refractory Materials," by D. W. Hubbard, B.Sc., and W. J. Rees, B.Sc., F.I.C. (7) "Drying Cracks," by C. E. Moore.

XUM

Hardness Testing Cast Iron.

Many methods have been evolved for testing the hardness of metals. The Brinell hardness number is at present perhaps the most widely known, but the Brinell method is not always applicable. When, for instance, the piece to be tested is a large one it cannot be put on the platform of the Brinell machine. It is therefore important to know whether it might be possible to convert the test values obtained by other testing methods into Brinell hardness numbers. Some experimental work on cast iron was recently carried out by H. Pinsl,* who examined the relationship between the Brinell method, the Shore scleroscope method, and the Poldi method. In the last method a steel ball is put between the casting to be tested and a steel sample, the hardness of which is known, and by a hammer blow spherical imprints are generated on the two samples; from the diameters of the imprints the Poldi hardness is calculated.

The Brinell test was made with a 10 m/m ball and a load of 3,000 kilos. applied on the test piece for 30 sec. In the Poldi test the steel sample used for comparison had a tensile strength of 44.4 t/sq. in. For the Shore test the surface of the sample was polished with emery paper up to grade O (brand Leitz, Wetzlar). Had the surface not been polished to this degree the amount of rebound of the hammer would be smaller, as was shown by preliminary experiments.

The experiments were made with ordinary cupola iron rich in phosphorus; the composition was as follows:—C, 3.3 to 3.4; Si, 1.8 to 3.0; Mn, 0.4 to 0.6; S, 0.06 to 0.19; P, 1.0 to 1.3 per cent.

In order to secure equal testing conditions for the three methods test bars 600 mm. in length and with a diameter of 30 mm. were prepared and cut into pieces of about 20 mm. The tests were taken on the cut surfaces polished as mentioned above. On the whole 20 bars with 280 pieces were examined; the average test values can be seen from Table I and Fig. 1. The nearly parallel course

Table I.

Brinell hardness H_B.	Corresponding values of		Ratio figures.		
	Shore hardness H_S	Poldi hardness H_P	$H_B : H_S$	$H_B : H_P$	$H_P : H_S$
145	28	53.8	5.20	2.73	1.92
148	29	54.0	5.13	2.74	1.86
150	31	56.4	4.87	2.69	1.82
159	33	55.5	4.83	2.87	1.68
165	34	58.5	4.87	2.82	1.72
169	35	58.0	4.84	2.91	1.66
174	36	60.0	4.85	2.90	1.66
181	37	61.0	4.90	2.97	1.66
185	41	61.7	4.52	2.99	1.51
207	42	68.0	4.74	3.05	1.61
228	48	75.0	4.76	3.04	1.56
230	49	75.5	4.70	3.04	1.54
231	50	78.0	4.63	2.97	1.57
247	51	82.5	4.85	3.00	1.62
250	52	82.0	4.82	3.07	1.58

of the Shore hardness and the Poldi hardness curves shows that the two methods are of the same character. For practical use the following ratio figures can be used with sufficient accuracy for ordinary cast iron rich in phosphorus:—

	For soft iron.	For medium-hard and hard iron.
(1) *To convert Brinell hardness into*		
a. Shore hardness	0.192	0.208
b. Poldi hardness	0.37	0.344
(2) *To convert Shore hardness into*		
a. Brinell hardness	5.2	4.8
b. Poldi hardness	1.9	1.7
(3) *To convert Poldi hardness into*		
a. Brinell hardness	2.7	2.9
b. Shore hardness.	0.53	0.59

In further investigations the relationship between the hardness and the microstructure was examined. The same test pieces were used as before. A relationship between the hardness number and the unetched sample, *i.e.*, the size and the distribution of the graphite, could not be stated. But this was the case when the samples were etched, thereby revealing the different constituents. Generally the hardness number increases when the microstructure changes as follows: Only ferritic, increasing amount of pearlite + some phosphide eutectic, the ferrite disappears and the phosphide eutectic increases, free cementite appears. As from a given section structures of different appearance can be obtained it is necessary to combine several structures to

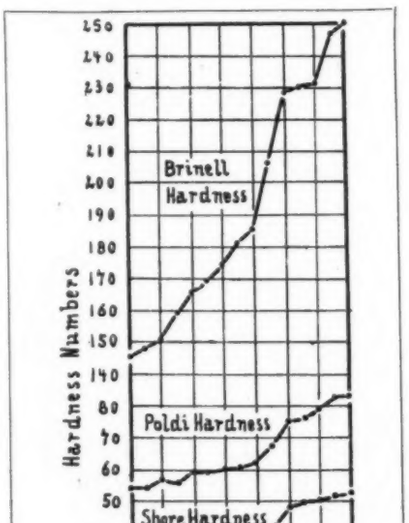


Fig 1.

form a representative type. The author gives some micrographs showing the main types with the corresponding hardness numbers. The accuracy of these examinations can be seen from the figures given in Table II; the hardness numbers were

Table II.

Sample No.	Shore hardness.	
	Estimated.	Examined.
1	42	39.8
2	38	36.8
3	40	36.7
4	48	53.0
5	30	31.7
6	51	50.8
7	51	48.4
8	30	33.2
9	33	32.6
10	40	38.1
11	44	41.6
12	36	37.2
13	40	41.0
14	31	28.0
15	34	32.2

estimated by means of the structure and then tested by the Shore method.

Besides the ordinary constituents discernible under the microscope two other factors influence the estimation of the hardness number from the microstructure. The first is the spread of the pearlite lamellæ. In the foregoing structures the pearlite was fairly closely packed. Other experiments, however, showed that with crucible iron and electro-furnace iron the pearlite furnishes a higher hardness number without affecting the machinability of the iron in a bad sense. The other factor which must be taken into account is

Table III.

Kind of pig.	Composition.						Brinell hardness.
	Gr.	C.C.	Si.	Mn.	S.	P.	
Amberg Pig III	3.71	0.08	1.44	0.30	0.011	0.97	105
Pig II	3.73	0.09	2.71	0.34	0.018	0.94	121
Hematite	3.00	0.04	5.35	2.00	0.020	0.18	138
Pig, German III	2.96	0.06	5.40	0.39	0.027	0.74	170
Pig, German I	2.58	—	7.62	1.35	0.020	0.29	184

the content of such components which enter into solid solution and are therefore not discernible under the microscope. Here it is the silicon content which deeply influences the hardness number; this effect can be seen from the figures given in Table III. By comparing hematite with pig German III it can also be seen that the influence of the phosphorus upon the hardness is much greater than that of the manganese.

* Giesserei-Zeitung, 1928, No. 14, pp. 417-424.

Barrow Hematite Steel Company, Limited.

Amended Scheme Carried.

The adjourned meeting of the holders of the 5 per cent. first debenture stock of the Barrow Hematite Steel Company, Limited, called to consider the amended financial proposals of the directors, was held in London on Friday, September 14.

Sir William Peat, who presided, explained the terms of the resolutions which were being submitted, and stated that proxies representing £545,107 had been received in favour of the scheme and £272,545 against, so that the necessary three-fourths majority in favour had not been secured.

Mr. G. Mure Ritchie, the chairman, reviewing the position of the company, said that the iron, steel and coal trades of Great Britain were to-day in such a depressed condition as had never before been experienced. Of all similar companies Barrow had lost least during this period of acute depression, and the modifications which were being sought from the debenture stockholders were the most moderate. During the last three or four years something like ten to twelve million tons of foreign steel had been imported into this country, which would and should under a rational system of tariffs have been made here. As a consequence there had been a scramble for orders, as there were not sufficient to go round. This was the main cause of the impossibility of the company meeting its debenture interest at the end of June last. Another cause was that three strikes during recent years had depleted the company's resources to an extent of no less than £187,000. If it had not been for these strikes, the company would not be in its present position. It was highly undesirable that the company should drift into a receivership. Assuming the country got back to anything like a normal state in these basic industries, with the modernisation of the works and colliery, and especially if safeguarding was introduced, it was quite certain, in his opinion, that the Barrow company would earn large profits. It was, therefore, of the greatest importance to keep the company in being. As the majority of proxies received in favour of the resolutions was not sufficient for them to be carried, he felt it his duty to tender his resignation from the board. He expressed the hope that the company's troubles would be surmounted and that it would be brought back to a state of prosperity. Mr. Frank Holt, his colleague on the board, had decided, in the circumstances, to resign also.

Sir William Peat said he felt that Mr. Ritchie had met the present demand of a section of the debenture holders as a man and gentlemen should meet them.

Mr. Douglas Broad, in moving the resolutions, said that so far as Mr. Ritchie was concerned there was certainly no personal animosity against him at all. Any differences with the board had been purely of policy and not with any individual members.

The resolutions were carried.

One of the oldest copper and brass foundries in Germany, Tietzens, of Bautzen, has collapsed quite unexpectedly, with liabilities of £350,000.

The Fuel Economy of the Cupola.

Some interesting experiments have been made by R. W. Müller * on the influence of the amount of blast (the coke charge being maintained constant) and the amount of charge coke (the blast being maintained constant) upon the output and the thermal efficiency of the cupola. The furnace used was one of the Sulzer type. The diameter of the melting zone was 27.56 ins.; above the melting zone the diameter increased to 39.37 ins. The furnace had two rows of tuyeres, the upper

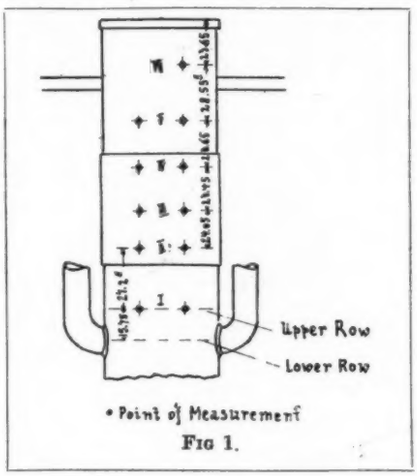


FIG 1.

row having 8 tuyeres of 2.95 × 2.95 ins. and the lower row 4 tuyeres of 4.33 × 5.51 ins. The ratio area of tuyeres to area of melting zone was 0.28. Holes for temperature measurements and the taking of gas samples were prepared in different heights of the back of the furnace; the location of the holes can be seen from Fig. 1. The temperature was measured with calibrated thermo-couples.

The bed of the cupola consisted of 990 lbs. of coke and 297 lbs. of limestone. When the upper

TABLE I.

Mixture No.	Si per cent.	Mn per cent.
I	1.30	1.26
II	1.82	1.11
III	3.29	0.93
IV	2.97	0.84

layers of the bed coke had become red hot the iron was charged. The iron charge consisted of 1,100 lbs. of iron, calculated amounts of coke and limestone, the amount of the latter being 30.0 per cent. of the coke charge. The chemical composition of the coke and the limestone was as follows:—

Limestone: SiO_2, 2.02; $Al_2O_3+Fe_2O_3$, 0.63; CaO, 53.35; MgO, 1.44; loss of ignition, 42.56; SO_4, trace; and P_2O_5, 0.091 per cent.

Coke: S, 1.01; ash, 10.49; moisture, 2.88; and C, 85.62 per cent.

* Giesserei-Zeitung, 1928, No. 14, pp. 425/9.

During the melting period the mixture was changed four times. The compositions of the different mixtures are given in Table I. Before changing the mixture a charge of coarse coke was interposed in order to separate the mixtures and to build up the coke bed.

Some of the experimental results are given in Table II and Figs. 2 and 3. The thermal efficiency is the ratio of the heat content of the molten iron to the latent heat content of the charged coke. The gain in heat caused by the exothermic reactions (oxidation of silicon, manganese, etc.) is not taken into account. From the data the following facts can be postulated: (1) When the coke charge is normal, the output and the temperatures of the iron and the slag decrease with the decreasing amount of blast. The ratio of combustion and the thermal efficiency are not influenced, except to a slight degree. (2) When the amount of blast is normal, the output, the thermal efficiency, and the combustion ratio

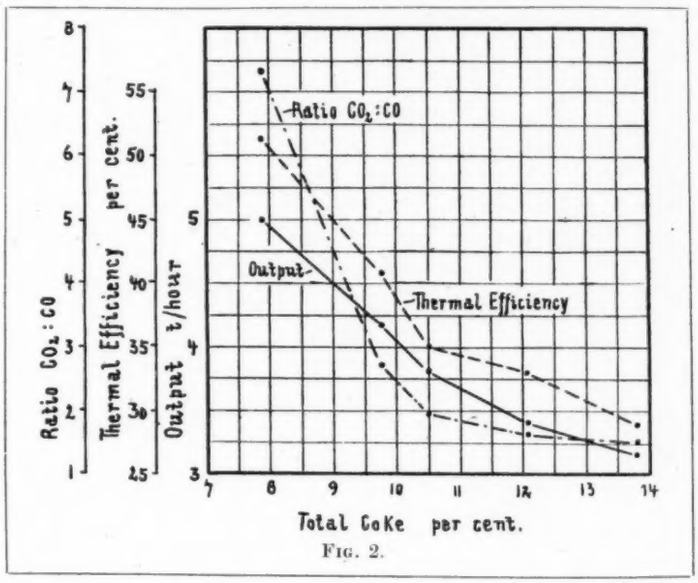


FIG. 2.

TABLE III.

	Mixture. I.	II.	III.	IV.		Mixture. I.	II.	III.	IV.
	Experiment 1.					Experiment 6.			
Si ..	1.10	1.47	2.65	2.49	Si ..	1.05	1.34	2.43	2.3
Mn ..	0.93	0.88	0.82	0.63	Mn ..	0.89	0.79	0.68	0.60
	Experiment 2.					Experiment 7.			
Si ..	1.12	1.42	2.71	2.61	Si ..	1.05	1.47	2.67	2.56
Mn ..	0.86	0.88	0.75	0.68	Mn ..	0.85	0.81	0.85	0.69
	Experiment 3.					Experiment 8.			
Si ..	1.07	1.34	2.58	2.58	Si ..	1.12	1.49	2.61	—
Mn ..	0.88	0.89	0.79	0.64	Mn ..	0.91	0.90	0.83	—
	Experiment 4.					Experiment 9.			
Si ..	1.16	1.40	2.64	2.55	Si ..	1.17	1.47	2.58	2.57
Mn ..	0.90	0.89	0.84	0.61	Mn ..	0.80	0.90	0.79	0.60
	Experiment 5.					Experiment 10.			
Si ..	1.47	1.45	2.73	2.64	Si ..	1.12	1.40	2.63	2.60
Mn ..	0.79	0.78	0.82	0.61	Mn ..	0.97	0.80	0.78	0.58

TABLE II.

Series No.	Exp. No.	Charge Coke. Per cent.	Total Coke. Per cent.	Blast. Cub. ft. per min.	Output. Tons per hour.	Melting Loss. Per cent.	Temp. of Iron at pour. Deg. C.	Temp. of Slag. Deg. C.	Thermal Effic. Per cent.	Ratio. CO : CO.
I	1	7.65	9.25	1,270	2.99	1.1	1,370	1,414	42.0	76 : 24
	2	7.60	9.08	1,590	3.56	0.97	1,433	1,460	43.8	74 : 26
	3	7.42	8.96	2,120	4.52	1.1	1,436	1,457	46.7	86 : 14
	4	7.24	8.99	2,260	4.42	1.1	1,440	1,468	44.4	74 : 26
	5	7.46	9.24	2,650	4.54	1.1	1,452	1,492	43.2	78 : 22
II	6	6.29	7.88	2,120	5.01	1.1	1,411	1,450	51.3	88 : 12
	7	8.79	9.74	2,120	4.17	1.1	1,445	1,485	40.7	73 : 27
	8	9.36	10.51	2,120	3.80	1.1	1,438	1,461	35.1	66 : 34
	9	11.12	12.08	2,120	3.40	1.07	1,420	1,443	32.9	62 : 38
	10	12.38	13.79	2,120	3.16	1.1	1,435	1,507	28.8	60 : 40

decrease with the increasing amount of coke; the temperatures of the iron and the slag, on the other hand, increase.

The melting loss is calculated from the amount of the charged iron and that of the tapped iron. This method of calculation is somewhat imperfect, inasmuch as the loss figure is influenced to a large degree by the surface condition of the pig. In judging the melting loss it is better to consider the decrease of the silicon and manganese contents of the mixture. By comparing Table III, where the composition of the tapped iron is recorded with Table I, it is to be seen that the melting loss does not exceed a certain limit, but in experiment No. 6, where the coke charge was 6.29 per cent.

The temperatures of the furnace in the different heights are recorded in Table IV. As the readings were taken near the lining they do not correspond to the temperature of the charge.

Any direct influence of the experimental conditions upon the composition of the slag and the mechanical properties of the iron could not be postulated.

From Table V it is interesting to note that a change in the volume of blast has only little influence upon the composition of the waste gases when the coke charge is normal. This statement is important with respect to the reactivity of the coke.

In order to determine the planes of equal temperature rods consisting of materials of different melting points were suspended perpendicular in the furnace. Looking from the charging door the rods were in the background, in the centre, at the left side and at the right side of the furnace.

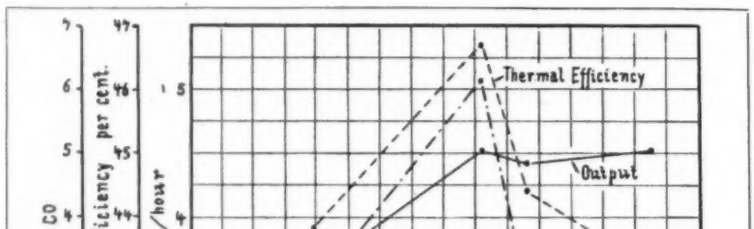


Fig. 3.

Table IV.

Series No.	Exp. No.	Point of Measurement No. II. Deg. C.	III. Deg. C.	IV. Deg. C.	V. Deg. C.	VI. Deg. C.
I	1	1,447	1,210	863	743	198
	2	1,327	1,183	961	614	145
	3	1,350	1,117	783	704	171
	4	1,410	1,085	751	464	141
	5	1,340	1,078	775	750	207
II	6	1,330	1,277	902	675	180
	7	1,360	1,260	862	768	175
	8	1,370	1,258	954	749	196
	9	1,380	1,355	1,235	778	297
	10	1,484	1,331	931	796	283

Table V.

Series No.	Exp. No.	Point No. II. CO_2	O_2	CO	Point No. III. CO_2	O_2	CO	Point No. IV. CO_2	O_2	CO	Point No. V. CO_2	O_2	CO	Point No. VI. CO_2	O_2	CO.
I	1	18.0	1.0	—	14.3	0.8	5.9	16.6	2.7	0.8	16.9	0.4	2.2	16.7	—	5.38
	2	15.1	0.1	—	17.3	0.5	0.13	18.2	1.5	0.6	17.7	0.2	1.1	16.9	0.1	6.0
	3	18.7	0.4	0.5	17.1	1.8	1.6	16.9	1.8	1.4	17.9	0.6	0.8	17.6	0.1	2.8
	4	11.3	0.4	7.9	18.5	0.5	1.6	—	—	—	17.4	3.9	1.0	16.7	0.1	5.9
	5	18.9	0.5	—	18.3	0.3	0.5	—	—	—	15.8	3.5	0.7	17.5	0.2	4.8
II	6	19.2	0.3	—	17.1	1.2	1.6	17.8	1.5	0.6	17.3	0.5	0.8	18.1	—	2.4
	7	16.3	—	—	15.7	3.7	0.05	11.7	6.9	1.7	18.3	0.1	3.0	16.5	0.1	6.1
	8	17.8	0.1	—	16.9	0.07	1.6	16.9	0.4	1.8	15.9	0.04	5.8	15.3	—	7.8
	9	17.0	0.5	—	17.7	0.15	1.3	17.2	0.8	1.8	17.2	—	2.8	14.8	—	9.2
	10	18.4	0.4	—	16.3	0.2	2.7	16.8	—	3.0	15.8	—	3.5	14.5	—	9.7

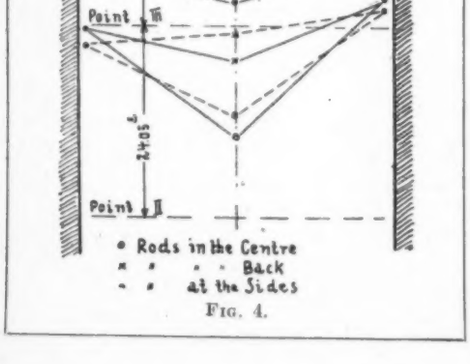


Fig. 4.

Some planes of equal temperature are given in Fig. 4.

The foregoing experiments show that the amount of the coke charge is controlled by the dimensions of the cupola, especially by the inner diameter. Exceeding the normal coke charge has a more deleterious effect than a moderate lack of blast for some time.

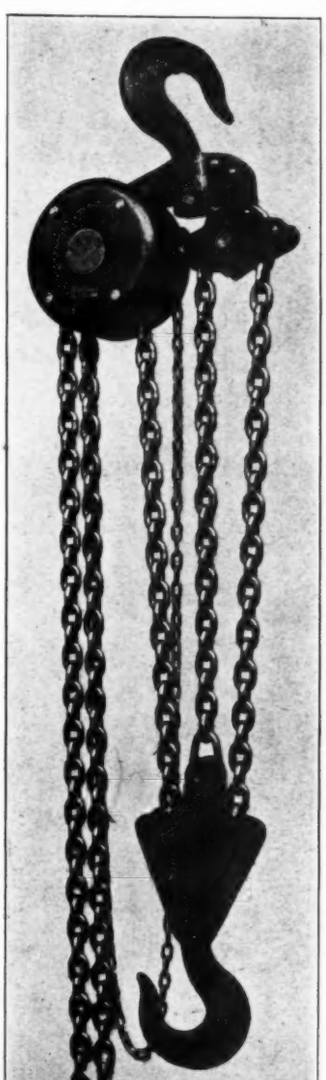
Iron and Steel Output in August.

The National Federation of Iron and Steel Manufacturers report that the number of furnaces in blast at the end of August was 130, a net decrease of one since the beginning of the month. The production of pig-iron amounted to 519,000 tons, compared with 537,800 tons in July and 596,100 tons in August, 1927. The August production included 164,700 tons of hematite, 193,400 tons of basic, 121,300 tons of foundry, and 25,200 tons of forge iron. Production of steel ingots and castings in August amounted to 648,300 tons compared with 666,900 tons in July and 643,100 tons in August, 1927.

The Furness Shipbuilding Company, Limited, of Haverton Hill-on-Tees, have received orders for a vessel of 6,500 tons and an oil tanker of 3,000 tons. Both vessels are for Canadian shipowners.

The "Exo" Pulley Block.

The pulley block illustrated, which is being placed upon the market by the Universal System of Machine Moulding & Machinery Company, Limited, 13-15, Wilson Street, London, E.C.2, marks an entirely novel advancement in the manufacture of pulley-blocks, being made entirely of high-quality steel; the side frames are made from rolled-steel plates, and the whole of the gears are case-hardened. This not only ensures a particularly robust construction, but it permits of a reduction of approximately 50 per cent. in the weight for equal lifting capacity against the standard-type blocks, with an almost corresponding reduction in actual size. These features, combined with the exceptionally small amount of head-room required, should render the "Exo" pulley-block of useful service for moulds fabricated in deep pits.



The "Exo" 5- to 10-Ton Pulley-Block.

The casing is made of pressed steel with rolled-steel plate sides. The ratchet wheel is of forged steel with the teeth machined from the solid and case-hardened. The screw-plate brake, the chain wheel and the gears are machine-cut from the solid. The blocks are fitted with electrically-welded chains which are annealed after finish.

Iron and Steel in Europe.

We have received from the Dillon, Read Corporation, Paris, an interesting publication entitled "Coal, Iron and Steel in Europe," by MR. E. F. WILLET, who points out in some introductory remarks, that the present study of the coal, iron and steel situation in Europe has been made for the purpose of determining as closely as possible which European countries have the strongest position in these industries at the present time, and in which countries the possibilities for future development seem to be most favourable. Particular attention has been paid to the export situation in order to determine which countries appear to be the most strategically located with respect to furnishing the international trade demand of the world for coal, and for iron and steel products.

The author has compiled numerous tables, the figures presented being limited to those for the more important producing countries of Europe, but in some cases figures for the United States and certain other countries have been used where their inclusion seemed to be particularly desirable. The position of the various countries with respect to production of, and trade in, coal, coke, iron-ore, pig-iron, steel ingots and semi-finished iron and steel products is indicated wherever statistics were obtainable. We append the author's conclusions:—

Germany.

Germany is unquestionably the leading iron and steel nation of Europe at the present time. This is true in spite of the fact that by the cession of Lorraine to France the division of Upper Silesia, the separation of Luxemburg from the German Customs territory and the incorporation of the Saar district in the French Customs area, Germany lost about 75 per cent. of her iron-ore production, 25 per cent. of her coal production, 30 per cent. of her steelworks, and almost 30 per cent. of her rolling mills.

When one bears in mind these physical losses the difficulties of converting the entire German industry from a war-time to a peace-time basis, the cessation of foreign trade during the war, the cutting-off of some of her foreign markets as a result of the losses of her colonies, the natural disinclination of certain other foreign markets to trade with a country that had just ceased to be an enemy, the demoralisation of the industry at the time of French occupation of the Ruhr district and the burdens borne by German industry on account of reparations, the surprising fact is not that Germany's relative importance has decreased considerably since before the war, but that she has made, and is making, such rapid strides in the iron and steel industry, and is regaining so rapidly her position in foreign markets.

A spectacular advance in iron and steel production began in Germany about May, 1927. This advance was due almost entirely to increased industrial activity within Germany, and as a result the German steelmakers appear not to have taken their usual interest in export markets. The high rate of production in Germany has continued into the current year. The demands of the German internal market have been slightly less active since the beginning of 1928, and it is probable that the German producers will again direct their attention more vigorously to export markets. In this connection, it is significant that early in 1928 they obtained from the Continental Steel Trust an increase of 50,000 tons per month in their export allotment. It should also be remembered that the approach of the period of full payments under the Dawes Plan may influence the German policy and furnish a further stimulus to export trade.

Germany's position among European countries may be summed up as one of strength in coal and coke, of weakness in iron-ore, of leadership in the production of pig-iron and steel ingots and of leadership in the production of, and foreign trade in, finished iron and steel products.

The United Kingdom.

The iron and steel industry in the United Kingdom is in a state of depression at the present time, and it is in general a much less important factor in the world iron and steel industry than it was prior to the war. In the post-war years to 1920 the industry in the United Kingdom was operating satisfactorily as a result of the necessity of meeting large demands for iron and steel of a peace-time rather than war-time nature which had accumulated during the years of the war, and also as a result of a post-war inflation. The end of 1920, however, showed a marked deflation which reacted disastrously upon most lines of British industry in 1921, this year of depression being similar, in both its causes and extent, to that in the United States in the same year.

The iron and steel industry recovered to a considerable extent during the years 1922 and 1923, but, contrary to the situation in the leading Continental countries, this recovery failed to extend through the years 1924 and 1925. One important cause for this was the artificial advantage in competition enjoyed by certain of the country's Continental rivals as a result of the inflation of their currencies.

The iron and steel industry in the United Kingdom in 1926 was demoralised as a result of the coal strike. This strike, coming as it did after several years of depression, was a serious blow to the position of the entire British iron and steel industry. In 1927, of course, production in most lines of the industry was not only greatly in excess of that in 1926, but in many cases exceeded that for the years 1924 and 1925. However, this fact may be explained as being due to the accumulation of unfilled orders during the shut-down in 1926 rather than to any real improvement in the intrinsic strength of the iron and steel industry of the United Kingdom. In spite of the comparatively large production in 1927, many of the large British companies produced at a loss, and, in general, the iron and steel industry in the United Kingdom at the present time may be regarded as being in a less satisfactory condition than that of any of the other important countries considered. The United Kingdom had a net export balance of more than 2,500,000 tons of iron and steel products in 1913, and a net import balance of about 200,000 tons in 1927.

In spite of the generally unfavourable picture that is given of the iron and steel industry in the United Kingdom as a result of a study of statistics, there are, nevertheless, several factors which tend to work in its favour. In the first place, British steel undoubtedly enjoys a reputation for quality, and it is noteworthy that British specifications are, in general, more rigid than those in France and Belgium. Another point in favour of British steel-makers is that their product has a firm hold in the British Colonies and in the Dominion markets. There are several reasons for this, among them being the fact that British steel enters these markets under a preferential tariff.

Moreover, it is sometimes purchased from sentimental and patriotic motives, although too much importance should not be given to this factor. Of more importance is the fact that steel required in the Colonies and Dominions for constructional purposes must be rolled to British sizes. This eliminates certain Continental firms from competition, although of course there are many that do roll British sizes. Finally, it should be remembered that many foreign concerns, such as railways in South America, for instance, are largely controlled by British capital. Although this does not necessarily mean that these concerns will systematically fill their requirements with British steel, it is a point in favour of the British exporter.

France and the Saar.

France and the Saar district are considered together inasmuch as the latter is now included within the French Customs territory, although its final disposition will not be decided until 1935, when a plebiscite will be taken. Moreover, in many instances it has been impossible to get figures for the Saar district separate from those for France.

France is more than self-sufficing with respect to iron ore, but must import a large part of the high-grade coal and coke required in her iron and steel industry. Her production of pig-iron and raw and semi-finished steel has developed very rapidly and she holds a leading position in the export of these products. The importance of France as a supplier of iron and steel in the world trade is due to a considerable extent to acquisitions from Germany. The territory she acquired from Germany had a productive capacity greatly in excess of its consumption requirements, and therefore France has had available a large surplus of iron and steel products which has found its way into international trade. The change in France's position may best be illustrated by the statement that her exports of iron and steel products increased from 630,000 tons in 1913 to approximately 6,000,000 tons, including the Saar, in 1927.

Belgium and Luxemburg.

These two countries are considered together for the reason that they form one Customs territory, and also because separate figures for the two districts are in many cases not available. Moreover, the two countries occupy a very similar position in the European iron and steel industry.

Luxemburg produces no coal or coke, while Belgium is more than self-sustaining in this respect. However, on the basis of 1927 figures, the two countries together have a net import balance of more than 6,000,000 tons of coal, or nearly 20 per cent. of their apparent total consumption and more than 2,000,000 tons of coke, or over 25 per cent. of their apparent total consumption. As regards iron ore, Belgium produces practically none, while the production of Luxemburg amounts to less than half the combined consumption of the two countries.

The real significance of Belgium and Luxemburg in the European iron and steel industry lies in the fact that they consume a smaller portion of their production than any of the other leading iron and steel nations of Europe. No less than 85 per cent. of Luxemburg's total steel production is exported. Due to the large proportion of their output which is available for export, these countries are of great importance in international trade in iron and steel products. Development of the industry in these countries has been steady and rapid since the war, and their output is now greatly in excess of that in 1913.

Poland.

The main importance of Poland from the standpoint of coal, iron and steel, lies in the fact that she possesses large reserves of coal, and is at present exporting substantial quantities of this product. Her iron-ore production is low, both in tonnage and in proportion to 1913, and the iron content of the ore is less than the average content of the reserves in any other important country in Europe. Her production of coke as well as pig-iron and steel ingots is low. Coke production in 1925 was nearly 20 per cent. less than in 1913, while production of pig-iron and steel ingots in 1927 was approximately 60 per cent. and 75 per cent. of the respective amounts produced in 1913, although it showed great improvement over 1926. The general situation in Poland is showing improvement during the current year.

British Empire Steel Corporation, Limited.—The report for 1927 shows an aggregate operating profit of $5,513,761, from which $1,476,013 has been deducted in partial provision for sinking funds, depreciation and depletion. Interest and discount on bonds and debentures, etc., amounted to $1,902,347, and the balance, $2,135,400, is shown as net profit for year. Deducting this from the deficit shown at December 31, 1926, amounting to $4,599,550, the deficit in consolidated profit and loss account at December 31, 1927, was reduced to $2,464,149. The directors are carefully studying the affairs of the Corporation and means that may be adopted for the betterment of its financial structure.

Making Turbine Nozzles.

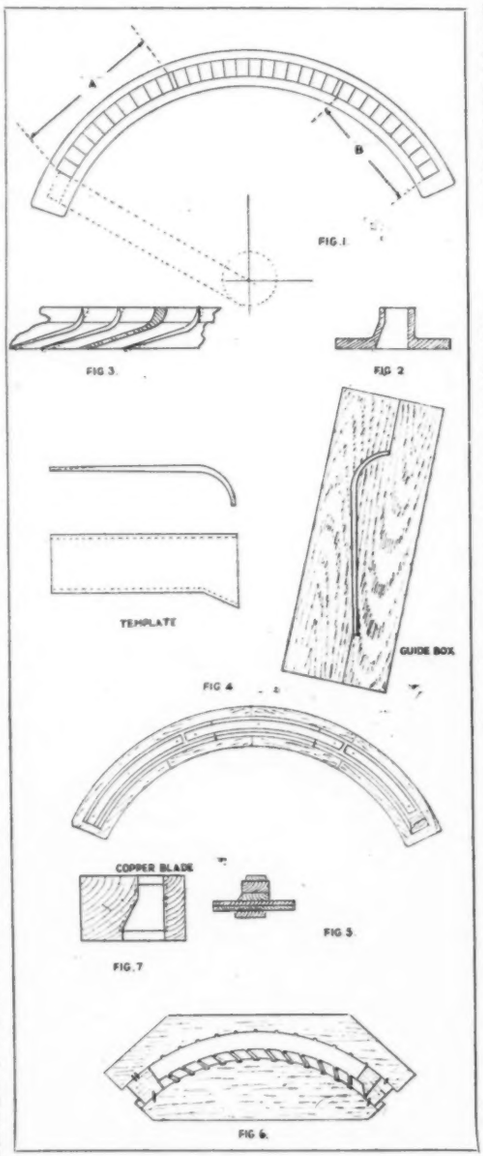
By Ben Shaw.

Nozzles are a very important part of the turbine arrangement, as they provide the means by which the steam passes from the steam chest or valve chamber to the blading. They are designed to suit the pressure of steam to be used so that a known quantity of steam will be projected on the blades in a given time. The blades attached to the rotor or spindle receive the steam first, and then it passes to the fixed and moving blades alternately. The blades or vanes in the nozzles are set at a suitable angle with face, so that the most effective use may be made of the steam pressure. A plan view of a common form of nozzle is shown in Fig. 1. This illustrates the face which comes in contact with the valve chamber. A section of the castings required taken on a line radiating from the centre is shown in Fig. 2, and the part section, shown at Fig. 3, indicates the angle and type of blades frequently used in connection with these nozzles. At one time it was the common practice to make the whole of the casting of tough bronze, usually admiralty bronze (88 Cu, 10 Sn, and 2 per cent. Zn), but when the blades were cast in this way they showed a tendency to buckle under very high pressures owing to the light section necessary, and, incidentally, it was very difficult to get a polished surface on these blades after the casting was made. The available space for these nozzles is limited, the blades being necessary for projecting the steam at the correct angle took up valuable space; hence their sectional area had to be reduced to a minimum. The use of copper blades instead of the ordinary cast-blades has reduced the difficulties considerably, and their use is now more frequently adopted, the copper being rolled or pressed to the required sectional shape and afterwards cut to the size of a template supplied by the pattern shop. These copper blades being very smooth, need little touching up after the casting has been made; there is therefore a reduction in surface friction with these blades compared with those that are composed of the same metal as the casting. It will be noted in Fig. 3 that the blades are finished off to a fine cutting edge, which are flush with both faces. It is not convenient to prepare and introduce the blades in the casting so that they carry these fine edges; they are therefore thickened off, as indicated by the dotted lines in Fig. 3.

While the moulding and casting of these nozzles is not very difficult, the accuracy of the blades is essential, and the patternmaker is largely responsible for their correct setting. In preparing the pattern work necessary it is customary to prepare a template and box for the blades at the outset. As these copper blades are to be cast in their correct relative positions, it is necessary that they be wider than the sectional opening in the nozzle. The metal thickness of the sides of these castings varies slightly, but, as a rule, it is about 5/16 or 3/8 in. The increased width of the blades must therefore be small in order that the chilling action will not impair the fluidity of the metal to such an extent as to prevent the successful running of the job. Usually the blades are made about ¼ in. wider so that ¼ in. is allowed at each side about which the molten metal sets. The template must therefore be enlarged for this allowance. It is also convenient and advantageous to provide a box having a shape cut out just similar to the copper blades desired, so that each one may be fitted in and cleaned off accurately. Both the template and the guide box, illustrated in Fig. 4, should be made of some hardwood like sycamore. The blades after being shaped to coincide with the guide box should have the edges tinned. This is not essential, but a better connection is made with the fluid metal, and consequently it is an advantage.

In the construction of the pattern it is important to maintain permanence of form, and to secure this end it is advisable to build it by means of a series of segments in order to secure a continuous grain. The method is indicated in Fig. 5, which shows a plan view and section of a suitable pattern. It will be noted that prints are carried on both faces, three being used on one side. They are separated from each other by the thickness of the web of cast metal, which is shown in Fig. 3.

Core prints are necessary on both sides to enclose the copper blades and give a stronger core. It is in the construction of the core-box that special attention must be given, particularly as



it is necessary to adjust it to suit the three cores required from it. The longest core carries twelve copper blades, the other two having eight and nine respectively. The box should be constructed to form the longest core, as shown in Fig. 6, and the ends adjusted to give the shape for the smaller ones. The two main sides of the box need to be prepared to follow the contour of the required core and the full height over the prints on the pattern. For convenience it is better to add the print thicknesses as separate pieces so that the recesses for the blades can more easily be accomplished. The positions for the blades must be marked off very accurately on each piece and in their correct relation to each other. When both sides of each piece are marked off, one of the blades may be used to determine the shapes on the edges which are to be recessed. After the shapes have been recessed to a depth of ⅛ in., the blades can be introduced and the ends secured. There are two methods of securing these ends to the box sides, both may be secured to the concave side; they are then convenient for stripping the core, or they may be secured so that one end is attached to each side, a method which facilitates alteration for the smaller cores, but increases the difficulty of stripping. It is advisable to secure the box in its various positions and mark each position carefully before setting the box to the largest size and introducing the blades. A section of the finished core-box showing the position of the blades is shown in Fig. 7. When the cores are being introduced into the prepared mould, it is important to note that the blades project the requisite amount from the sides, and that they are quite free of sand grains. Admiralty gunmetal is generally used for the casting, and by taking the usual precautions associated with this alloy a reliable casting will be produced which will give good results. When the casting has been completed the edges of the blades are easy of access for the requisite knife edge finish.

Contracts Open.

Angora, October 13.—Zinc, for the Direction Generale des Fabriques Militaires, Angora. The Department of Overseas Trade. (Reference A.X. 6806.)

Bruton, Som., October 6.—5,016 yds. of 6-in. cast-iron main, for the Wincanton Rural District Council. Mr. A. J. Allen, Half Moon Street, Sherborne. (Fee £2 2s., returnable.)

Durban, November 9.—Cast-iron pipes and specials, for the Borough Council of Durban (Water Engineer's Department). The Department of Overseas Trade. (Reference A.X. 6849.)

Johannesburg, October 25.—Buffers, crossheads and drawbars, for the South African Railways and Harbours. The Department of Overseas Trade. (Reference A.X. 6810.)

Southend-on-Sea, October 9.—Four miles of 9-in. cast-iron pipe, etc., for the Corporation. Messrs. Dodd & Watson, County Chambers, Corporation Street, Birmingham. (Fee £2, returnable.)

Watford, October 5.—1,120 yds. of 18-in. cast-iron rising main, etc., for the Town Council. Mr. W. W. Newman, borough engineer. (Fee £2 2s., returnable.)

Ahmednagar, India, October 16.—Oil engine-driven alternator sets and switchgear, for the Indian Stores Department. The Department of Overseas Trade. (Reference B.X. 4714.)

Antwerp, October 15.—Two hydraulic capstans, for the Antwerp Municipality. The Department of Overseas Trade. (Reference A.X. 6841.)

Constantza, October 1.—One electric portal crane and two goods lifts, for the Port Authorities. The Department of Overseas Trade. (Reference A.X. 6797.)

Johannesburg, November 8.—Electrically-driven overhead travelling cranes, for the South African Railways and Harbours. The Department of Overseas Trade. (Reference A.X. 6815.)

London, S.E., October 1.—Three-ton steam or electric travelling crane, etc., for the Greenwich Borough Council. The Borough Engineer and Surveyor, Town Hall, Greenwich, S.E.10.

Newton Abbot.—About 10 tons of 6-in. and a similar quantity of 9-in. new or second-hand cast-iron pipes, for the Rural District Council. The Highway Surveyor, 9, Marlborough Terrace, Bovey Tracey, Devon.

Wellington, N.Z., November 11.—One turbine pump, etc., for the Corporation. The Department of Overseas Trade. (Reference A.X. 6796.)

FLUCTUATIONS IN THE VALUE of the shares of the Duffield Iron Corporation, Limited, have taken place following rumours regarding negotiations in Germany. The company state that they have recently appointed an authorised agent in Germany, but no negotiations with any German steel corporation have yet been started. An announcement of success or failure is therefore premature.

DEMAG AKTIENGESELLSCHAFT, of Duisburg, have appointed Messrs. Maurice Warlow & Company, 12, Victoria Street, London, S.W.1, as their agents in Great Britain so far as their main products are concerned. This appointment will make no alteration to the existing arrangements of the Demag firm with the Aabacas Engineering Company, Limited, Liverpool, who handle their electric pulley blocks, or the Rotary Air Compressor Company, Limited, London, who are handling their rotary and reciprocating air compressor plants.

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Trade Talk.

DR. A. B. EVEREST has been appointed metallurgist to the Bureau of Information on Nickel, Limited, and after November 1 will be domiciled in London.

FOLLOWING THE closing down of the iron and steel works of Messrs. Robert Heath & Low Moor, Limited, of Biddulph, North Staffs, more than 1,600 men have been thrown out of employment.

CONSIDERABLE DAMAGE has been caused by fire at the Ystalyfera Tinplate Works. The fire was confined to the mill department, oil stores, and dynamo department, where the roof was destroyed.

WITH THE OPENING of the Michaelmas term, there will be available at Harrow School a foundry and testing department as an adjunct to the engineering workshops.

THE NORTHUMBERLAND SHIPBUILDING COMPANY (1927), LIMITED, Howdon-on-Tyne, have booked orders for two cargo vessels of about 9,000 tons each. One of the vessels is to be a motorship which will be fitted with Doxford Diesel engines.

MR. HERBERT WARNER, head of Warner & Company, Limited, pig-iron manufacturers, of Cargo Fleet, Middlesbrough, left £93,041. He left £200 to each of his servants who have been in his employ for seven years, and an additional £30 for each year.

SIR JOHN PRIESTMAN & COMPANY, of Sunderland, have booked an order from Newport shipowners for three cargo steamers of about 6,500 tons each. The engines are to be supplied by Messrs. George Clark, Limited, of Sunderland.

THE GERMAN RAILWAY MANAGEMENT has sold 25 secondhand locomotives to the Yugoslav Railway Company, and is negotiating for the sale of more engines. About 250 heavy locomotives are needed on the Yugoslav system, and the German builders are seeking a basis for the supply of these without being compelled to grant extended credit terms.

MESSRS. H. & E. CRUNDALL, LIMITED, of 52, Coal Exchange, London, E.C.3, announce that they have transferred the foundry supplies section of their business of the Kinrix Foundry Supplies Company, of Great Western Railway Depôt, Warwick Road, Kensington. The telephone number is 0273 Western. The partners in the new concern are Mr. T. A. B. King and Mr. H. E. Ricketts.

THE DEPARTMENT OF OVERSEAS TRADE have received a letter from a Canadian company who desire to obtain information as to the cost of the installation of a 3,500-h.p. turbine, direct-coupled to a three-phase generator. Firms desiring further particulars of this inquiry should apply to the Department at 35, Old Queen Street, London, S.W.1, quoting reference number B.X. 4728.

MESSRS. CAMMELL, LAIRD & COMPANY, LIMITED, of Sheffield, have recently delivered to the Firth-Derihon Stampings, Limited, Sheffield, what is thought to be the heaviest steel casting ever made. The casting in question was a hammer block, and weighed as cast 140 tons, and after machining 95 tons. It is 6 ft. 1 in. high, whilst the base is 9 ft. 2 in. x 10 ft. 2 in. There were 28 holes to be cored out.

MR. J. E. JAMES, a director of the Cargo Fleet Iron Company, Limited, speaking at Middlesbrough recently, declared that if Middlesbrough people would interest themselves in the question, they could give a definite lead in the matter of safeguarding the iron and steel industry. He had seen the conditions in Belgium, France and Germany under which iron and steel was produced, and they were not wanted here. He could say with every confidence that safeguarding of iron and steel and the production in this country of these imported materials would lower and not raise the price of iron and steel.

A PERIOD OF 120 years of trading, throughout which the business has been owned by the same family, has been completed by the firm of J. and J. Harriman & Company, wrought-iron ware manufacturers, of Middle Row, Wolverhampton. The business was founded in 1808 by Mr. Joseph Harriman, and in 1843 was transferred to his two sons, John and Joseph Harriman, who were assisted by their nephew Mr. J. T. Law, who eventually became sole proprietor. Some few years before Mr. Law's death in 1919 he transferred the business to his three sons—Mr. John H. Law, Mr. Joseph H. Law, and Mr. Charles C. Law, who are the present proprietors.

THE STANDING COMMITTEE (General Merchandise) appointed by the Board of Trade, have reported on their inquiry as to whether imported pumps of all descriptions should be required to bear an indication of origin. They recommend that imported pumps made wholly or mainly of metal, whether imported complete or in parts, should bear an indication of origin at the time of sale or exposure for sale in the United Kingdom, excepting only small hand-operated pumps for agricultural, surgical and scientific purposes, and cycle and motor-car pumps, etc. The indication of origin is to be cast or incised on each pump in a conspicuous manner.

MESSRS. STEIN & ATKINSON, LIMITED, of 47, Victoria Street, London, S.W.1, have recently received a number of interesting contracts, among which is one for a battery of soaking pits of the "Stein" recuperative type for Messrs. Richard Thomas & Company, Limited, Scunthorpe. These pits are the first of their type to be installed in this country, being of the recuperative as opposed to the more usual regenerative type, and are designed in this instance for the use of the alternative fuels, producer gas, blast-furnace gas, and coke-oven gas. Existing installations in France and America, supplied by Messrs. Stein & Atkinson's associated companies in those countries, have been giving extremely good results.

IN VIEW OF the present depressed condition of industry, Sir Alfred Herbert has written a letter to the Press in the expressed hope of counteracting the natural tendency for despondency. The machine-tool trade, he remarks, is rightly looked upon as one of the barometric industries, it being the basis on which all manufacture ultimately depends. In common with most other industries, it has passed through a period of depression since the war, but at the Machine Tool and Engineering Exhibition there has been the most widespread optimism, which is not without foundation. The volume of orders on hand in the industry, Sir Alfred asserts, is greater than at any time since 1920, and many machine-tool makers are unable to cope with the demand, in spite of the fact that overtime is general throughout the industry and night shifts are being worked in many shops. It would appear that the lesson that efficient equipment is the first essential of manufacturing success is being more and more fully recognised. There is besides a fuller recognition that labour-saving machinery not only reduces the cost of production and increases the volume of trade, but also brings about steady increases in the rewards of those who operate such machinery.

Reports and Dividends.

Butterley Company, Limited.—No quarterly interim dividend.

British Aluminium Company, Limited.—Interim dividend of 4 per cent., less tax.

Coltness Iron Company, Limited.—Interim dividend on the ordinary shares of 2½ per cent., actual, less tax.

Cammell Laird & Company, Limited.—No interim dividends on the cumulative preference or ordinary shares.

Stewarts & Lloyds, Limited.—Interim dividends at the rate of 6 per cent. per annum on the preference shares, and at the rate of 10 per cent. per annum on the preferred ordinary shares.

Ibbotson Brothers & Company, Limited.—Profit, £14,439; interest and bonus on the fully-paid shares, £5,263; brought forward, £74,600; dividend of 7½ per cent., tax free; carried forward, £76,771.

Dalmellington Iron Company, Limited.—Profit, after providing for taxation, depreciation, etc., £20,651; brought forward, £10,607; interim preference dividend of 5 per cent., £6,500; ordinary dividends totalling 5 per cent., £13,650; carried forward, £11,109.

Obituary.

DR. ING. KURT SORGE, Hon. President of the German Federation of Industries and a director of Krupps, has died at the age of 73.

MR. THOMAS M. LEWIS, who has died at Penistone, aged 88, was manager of the Yorkshire Steel and Iron Works of Messrs. Cammell, Laird & Company, Limited, for many years, but retired about 15 years ago.

Wills.

BERREY, A. E., of Keighley, a founder of the Rustless Iron Company, Limited ...	£13,741
PEECH, A. A., of Dore, Derbyshire, formerly a director of Messrs. Steel, Peech & Tozer, Limited, Sheffield	£70,307
COOPER, P. B. S., a director of Messrs. Spurrier Glazebrook & Company, Limited, Manchester	£49,921
MIDDLETON, E., of Sheffield, general secretary of Messrs. John Brown & Company, Limited	£16,718
TAYLOR, G. B., of Moseley, director of Messrs. Charles Taylor (Birmingham), Limited, machine tool makers	£5,973
DENHOLM, J. A., of Dalmuir, engineer, for many years with Messrs. William Beardmore & Company, Limited ...	£2,822

Personal.

MR. T. W. BROWN, who after 30 years' service has resigned his position as head foundry foreman to Messrs. Thos. Firth & Sons, Limited, Sheffield, has been the recipient of substantial gifts from both the workmen and staff. From the former he received a handsome wireless set, and from the latter a set of

MR. T. W. BROWN.

stainless hearth furniture and a case of Treasury notes. Mr. Brown has been a prominent member of the Institute of British Foundrymen, and has contributed three Papers to its proceedings, one in collaboration with Mr. F. A. Melmoth. The merit of his contributions has been recognised by the Institute, which has awarded him its diploma. The good wishes of the industry will be with him in his well-earned retirement.

MR. H. E. METCALF has resigned his position with Messrs. Babcock & Wilcox, Limited, to become general manager of Ruths Steam Storage, Limited.

LORD MELCHETT, accompanied by Mr. and Mrs. Henry Mond, sailed for New York last week, whence Lord Melchett will proceed immediately to Toronto and Coniston to inspect the mines of the Mond Nickel Company. He will be joined at Montreal by Sir Harry McGowan, and the party will spend three weeks at New York for business purposes.

MR. RICHARD JOSEPH BEAVIS, one of the oldest foundry workers in Derby, together with his wife, celebrated their golden wedding on Thursday. Mr. Beavis is eighty years old and his wife eighty-five. Mr. Beavis, who is well known to the trade and particularly among the older men, was for a period of 22 years associated with Ley's Malleable Castings Company, Limited.

MR. J. M. ESPANA has been decorated by the French Government. He has been nominated to the grade of Chevalier of the National Order of the Legion of Honour. Mr. Espana is commercial director of Messrs. Bonvillain & Ronceray, the well-known moulding machinery manufacturers. He has been the recipient of many decorations from the Spanish Government. He was the originator of the recent Spanish Foundry Congress.

MR. WILLIAM T. MACLELLAN, managing director of Messrs. P. & W. MacLellan, Limited, engineers, 129, Trongate, Glasgow, has completed fifty years' connection with the firm. He received a presentation from the employees. The gift consisted of a 6-valve wireless set, and Mr. MacKinnon, in making the presentation, offered congratulations on the happy occasion. Their managing director, he said, carried through many important jobs, especially during the war. From the British Government he was honoured with the C.B.E., while the French, Belgian and Italian Governments also showed their appreciation of services rendered. In thanking the employees, Mr. MacLellan said that this was the second century of the firm, which was founded in 1811.

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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—The end of the current quarter finds the market for Cleveland pig-iron a shade more active than it has been for some time past, attendances on 'Change having increased to something like normal average, with business slightly less restricted and prospects of expansion somewhat improved. There are, however, still many difficulties to surmount, and the trade indicator is not yet pointing to "set fair." Nevertheless, the trend of events is in the right direction. Conditions at the English foundries vary. Some are slack, others very busy; but, on the whole, the foundries are buying pig-iron a little more freely, being now convinced that a decline in prices is out of the question. Foreign sales of Cleveland pig-iron are very restricted. In few markets does Cleveland material approach a competitive price, and of the current output all but a very small proportion indeed is absorbed by home industries. Meanwhile prices are firm and unchanged as follow:—No. 1 Cleveland foundry iron, 68s. 6d. per ton; No. 3 G.M.B., 66s.; No. 4 foundry, 65s.; No. 4 forge, 64s. 6d. per ton, all f.o.t. or f.o.b.

With steadily increasing activity in the steel trade, the demand for East Coast hematite reflects a corresponding expansion both in actual business and in the volume of inquiries, while prices have also taken an upward tendency. Stocks are being cleared out rapidly, weak sellers eliminated, and makers are now able to insist on a price more nearly approximating to, if it does not actually cover, the cost of production. This week 70s. is the generally recognised market rate for East Coast mixed numbers, and 70s. 6d. for No. 1 quality. On the North-West Coast also prices are firm, with Bessemer mixed numbers quoted at 68s. 6d. per ton at works.

LANCASHIRE.—Prices of Midland foundry pig-iron having been practically stabilised in local markets, buying movements are mainly confined to consumers' current needs, with a few forward contracts negotiated when favourable terms can be obtained. Quotations rule firm, as follow:—Derbyshire and Staffordshire No. 3 foundry, 67s. to 67s. 6d.; Cleveland, 79s.; and Scottish, from 87s. 6d. to 90s., all per ton delivered Manchester or equal.

THE MIDLANDS.—Demand for foundry pig in this area continues erratic, few consumers buying more than sufficient to meet current requirements. Quotations remain firm and unchanged, with Northants. No. 3 quality at 55s. to 56s., Derbyshire 59s. to 60s., and North Staffordshire 60s., all f.o.t. furnaces.

SCOTLAND.—While an improved demand for pig-iron is slow to materialise, market circles continue in a more hopeful mood in regard to the future, and prices are firm and unchanged. The Scottish foundries, however, are not finding new work coming out as they would like, and until this alters they do not feel inclined to come into the market for quantities of pig-iron beyond their immediate requirements.

Finished Iron.

With the near approach of the quarterly meeting at Birmingham, some slight improvement in the conditions of this branch of the industry may be anticipated, though it must be admitted that so far little justification for optimistic views in that direction can be found in the present position of the trade. It may, however, be noted that makers of Staffordshire marked bars report that the recent improvement is still maintained, and no difficulty is experienced in getting the present level of £12 per ton at works for this grade. It is not possible to admit, however, any improvement in the demand for crown iron and the cheaper grades of iron. Orders for any heavy tonnage are very difficult indeed to acquire, and there continues to be much competition for the limited amount of business which is developing. Quotations vary from £9 to £9 15s. for crown quality, and nut and bolt bars can be obtained from £8 12s. 6d. to £8 17s. 6d., delivered to the Darlaston district.

Steel.

Although the autumn demand has not yet fully matured, the principal markets for steel are developing a distinctly improved tone, and the prospects may be regarded as fairly favourable to increasing trade. At Sheffield this tendency is evidenced in the case of basic billets, for which there is a better demand. Acid billets, on the other hand, are quieter. There is some activity in cold rolled strip. In some directions the output of steel is being increased. Rather more electric steel is being turned out, but no expansion in open-hearth steel is noted. Crucible steel production is not on a satisfactory scale. In the tinplate market, transactions generally are reported on a basis of 18s., and the tendency may be called firm, with makers' quotations ranging round 18s. to 18s. 3d. basis for coke qualities, net cash, f.o.b. South Wales ports.

Scrap.

Very little movement can be observed of late in the chief markets for foundry scrap material, with prices practically unchanged since previously reported. At Middlesbrough inquiries are on a limited scale, though heavy cast iron keeps steady and unchanged, ordinary quality being offered at 60s. and machinery quality in handy pieces at 65s. per ton. In Scotland the cast-iron scrap market is still unchanged, and it is rather difficult to find outlets for machinery metal, even at 65s. to 66s. Ordinary heavy cast-iron scrap, suitable for foundries, is still at 61s. 3d. to 62s. 6d. Old cast-iron railway chairs are quoted at 65s. to 66s., and light cast-iron scrap at 57s. 6d. The above prices are all per ton, delivered f.o.t consumers' works.

Metals.

Copper.—There has been no abatement of steadiness as concerns the current business passing in warrant copper, quotations for which, at the week-end, marked a further advance in values. A little more interest has also been taken in forward metal, with the result that there has been a slight widening of the difference between cash and forward prices. In America the price of copper has advanced, and Copper Exporters, Incorporated, now quote £70 10s. c.i.f. Great Britain.

Closing quotations are :—

Cash.—Thursday, £64 1s. 3d. to £64 2s. 6d.; Friday, £64 8s. 9d. to £64 11s. 3d.; Monday, £64 10s. to £64 12s. 6d.; Tuesday, £64 12s. 6d. to £64 15s.; Wednesday, £64 11s. 3d. to £64 12s. 6d.

Three Months.—Thursday, £64 12s. 6d. to £64 15s.; Friday, £65 to £65 2s. 6d.; Monday, £65 2s. 6d. to £65 5s.; Tuesday, £65 5s. to £65 6s. 3d.; Wednesday, £65 2s. 6d. to £65 3s. 9d.

Tin.—The upward movement in tin values evidenced of late has been doubtless stimulated by the increasing demand at home and abroad from the tinplate industry, the August statistics showing that production in America amounted to 4,200,000 boxes, this making the fourth successive month in which the production has exceeded 4,000,000 boxes. The announcement of the recent agreement between the Welsh and American tinplate interests has also distinctly benefited the market, and operators anticipate still better conditions if, as they believe is possible, South Wales and Germany effect some sort of understanding with regard to the European market.

Official closing prices :—

Cash.—Thursday, £216 15s. to £217; Friday, £219 5s. to £220; Monday, £220 7s. 6d. to £220 10s.; Tuesday, £223 10s. to £224; Wednesday, £223 to £223 10s.

Three Months.—Thursday, £213 7s. 6d. to £213 12s. 6d.; Friday, £214 15s. to £215; Monday, £215 10s. to £215 15s.; Tuesday, £219 to £219 5s.; Wednesday, £218 10s. to £218 15s.

Spelter.—Business in the market for ordinary spelter during the current week has continued quiet and uneventful, with values more or less stationary at the present low levels. Reports from the Continent indicate that steadiness is the dominant note; stocks, which are not large, are still held firmly, and holders show but little inclination to part with any appreciable quantities at ruling values.

Daily quotations are :—

Ordinary.—Thursday, £24 7s. 6d.; Friday, £24 7s. 6d.; Monday, £24 6s. 3d.; Tuesday, £24 6s. 3d.; Wednesday, £24 2s. 6d.

Lead.—Consumptive demand for soft foreign pig continues to be steadily maintained, with prices but little changed during the week. In proof that due balance between demand and supply seems to have been established, the conference of lead producers, held on Monday, September 17, has decided to make arrangements to prevent any actual increase in present production. The fact that no action to cut down supplies is to be taken should be considered a point in favour of the metal.

Closing prices :—

Soft Foreign Prompt.—Thursday, £22 2s. 6d.; Friday, £22; Monday, £21 18s. 9d.; Tuesday, £21 15s.; Wednesday, £21 15s.

Catalogue Received.

Foundry Equipment—Messrs. Sterling Foundry Specialities, Limited, Sterling Works, Bedford, has favoured us with an advance copy of their catalogue No. 37. It is a comprehensive, well-written and adequately illustrated 44-page pamphlet, and outlines in its extensive moulding box section a brilliant example of elastic rational standardisation. As raw material only nine sections of channel steel bars are used, but eliminating the length dimension these boil down to two . A similar story is applicable to the box pins. Yet from these few standardised parts an extremely wide range of boxes is made available. Modifications based on founder's personal experience are constantly being incorporated in the finished article, without departing radically from the basic idea. From these generalisations it will be appreciated that as a catalogue it presents a real lesson in what we have termed "elastic rationalisation." The last three pages are devoted to illustrated descriptions of foundry wheelbarrows and core oven trucks. Here again a large range has been made available through the utilisation of a limited number of standardised parts.

AN ACCOMPLISHED FACT

A Really Low Sulphur and Carbon Cylinder Iron at a reasonable price—the aim of the Foundry Trade for years.

LOWCAR

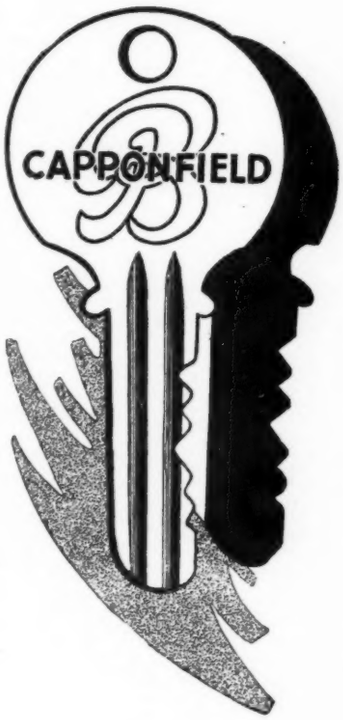
Carbon from 1.80 with a Sulphur of 0·01—0·03% maximum. Ten tons or more to your definite requirements and the analysis guaranteed.

A special grade for motor cylinders.

Tensile strength 16/19 tons with 20/25% Lowcar.

BESSLER, WAECHTER & Co., Ltd.,
SALISBURY HOUSE, LONDON, E.C.2.

The Key to Better Castings*



Capponfield

Hot "H.B." Blast

*THE blowing-in of the Capponfield Blast Furnaces meets the demand for a good class brand of South Staffordshire Foundry Iron, produced under carefully controlled conditions to comply with modern foundry requirements.

BRADLEY'S Capponfield Hot Blast is an excellent grade of iron, supplied with low phosphorus, low sulphur and medium manganese contents. The silicon content is supplied to suit the specific requirements of each customer, and a complete analysis of each cast is available. The addition of Capponfield Iron to your mixture is highly desirable for the production of good class engineering and general castings at competitive prices. Capponfield "H.B." means Strength plus Easy Machining.

3 Perfect Grades

Capponfield H.B.
(HOT BLAST)

Capponfield W.B.
(WARM BLAST)

Capponfield C.B.
(COLD BLAST)

Bradley's PIG IRON

"Capponfield Quality"

All Capponfield Irons are direct blast furnace products. Bradley's well-known Refined Irons are made at the Darlaston Works.

BRADLEY & FOSTER LIMITED

CAPPONFIELD AND DARLASTON, STAFFS

(All communications should be addressed to Darlaston).

TELEPHONE: DARLASTON 16 (Private Branch Exchange). TELEGRAMS: BRADLEY'S, DARLASTON

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	64 11 3
Three months	65 2 6
Electrolytic	71 5 0
Tough	67 10 0
Best selected	68 0 0
Sheets	94 0 0
India	78 5 0
Wire bars	71 12 6
Do. September	71 12 6
Do. October	71 12 6
Ingot bars	71 12 6
H.C. Wire rods	75 12 6
Off. av. cash, August	62 10 2 17/24
Do. 3 mths., August	62 18 11 11/24
Do., Sttlmnt., August	62 10 4 1/12
Do., Electro, August	69 0 0
Do., B.S., August	65 14 2
Aver. spot price, copper, Aug.	62 10 2½
Do., Wire bars, August	69 5 0
Solid drawn tubes	13½d.
Brazed tubes	13½d.
Wire	10d.

BRASS.

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	10½d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	10½d.
Wire	9½d.
Rolled metal	9½d.
Yellow metal rods	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£ s. d.
Standard cash	223 0 0
Three months	218 10 0
English	222 10 0
Bars	224 0 0
Straits	225 10 0
Australian	224 5 0
Eastern	221 5 0
Banca	228 10 0
Off. av. cash, August	212 19 10 7/12
Do., 3 mths., August	210 0 2 3/12
Do., Sttlmt., August	212 19 1 1/12
Aver. spot, August	212 19 10½

SPELTER.

Ordinary	24 2 6
Remelted	22 15 0
Hard	19 0 0
Electro 99.9	27 15 0
English	24 12 6
India	20 10 0
Zinc dust (Nom.)	35 5 0
Zinc ashes	7 15 0
Off. aver., August	24 12 6 15/24
Aver., spot, August	24 10 9½

LEAD.

Soft foreign ppt.	21 15 0
English	23 5 0
Off. average, August	21 12 7 1/12
Average spot, August	21 12 8

ZINC SHEETS, &c.

Zinc sheets, English	33 0 0
Do. V.M. ex whf.	31 5 0
Rods	39 0 0
Boiler plates	29 0 0
Battery plates	30 10 0

ANTIMONY.

Special brands, Eng.	59 0 0
Chinese	39 0 0
Crude	33 10 0

QUICKSILVER.

Quicksilver	24 15 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	7 17 6
45/50%	12 0 0
75%	19 0 0
Ferro-vanadium—	
35/50%	14/- lb. Va.
Ferro-molybdenum—	
70/75% c. free	4/3 lb. Mo.
Ferro-titanium—	
23/25% carbonless	1/2 lb.
Ferro-phosphorus, 20/25%	£18 0 0
Ferro-tungsten—	
80/85%, c. fr.	1/3 lb.
Tungsten metal powder—	
98/99%	1/7 to 1/7½ lb.
Ferro-chrome—	
2/4% car.	£30 0 0
4/6% car.	£21 7 6
6/8% car.	£20 12 6
8/10% car.	£20 0 0
Ferro-chrome—	
Max. 2% car.	£32 15 0
Max. 1% car.	£37 0 0
Max. 0.70% car.	£42 0 0
70%, carbonless	1/- lb.
Nickel—99%, cubes or pellets	£175 0 0
Ferro-cobalt	9/- lb.
Aluminium 98/99%	£98 0 0
Metallic chromium—	
96/98%	2/7 lb.
Ferro-manganese (net)—	
76/80%, loose	£13 15 0
76/80%, packed	£14 15 0
76/80%, export	£14 10 0
Metallic manganese—	
94/96%, carbonless	1/6 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£9 2 3
Finished bars, 18% tungsten	£9 2 9

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 1/8 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ¼ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/-lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—

Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

South Wales—	£ s. d.	£ s. d.
Hvy. steel	3 7 0	to 3 8 6
Bundled steel and shrngs.	3 2 6	to 3 7 6
Mixed iron and steel	3 0 0	to 3 2 0
Heavy cast iron	2 16 0	to 2 18 0
Good machinery for foundries	3 2 6	
Cleveland—		
Heavy steel	2 15 0	
Steel turnings	2 8 0	
Cast iron borings	2 1 6	
Heavy forge	3 10 0	
Bushelled scrap	3 0 0	
Cast-iron scrap	3 2 6	
Lancashire—		
Cast-iron scrap	3 0 0	
Hvy. wrought	2 17 6	
Steel turnings	2 2 6	

London—Merchants' buying prices delivered yard.

Copper (clean)	52 0 0
Brass	38 0 0
Lead (less usual draft)	18 0 0
Tea lead	15 10 0
Zinc	16 0 0
New aluminium cuttings	66 0 0
Braziery copper	48 0 0
Gunmetal	49 0 0
Hollow pewter	150 0 0
Shaped black pewter	105 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	68/6
Foundry No. 3	66/-
Foundry No. 4	65/-
Forge No. 4	64/6
Hematite No. 1	70/6
Hematite M/Nos.	70/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	78/6
,, d/d Birm.	86/-
Midlands—	
Staffs. common*	67/6
,, No. 4 forge	56/-
,, No. 3 fdry.	60/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	52/6
,, fdry. No. 3	55/6
Derbyshire forge	59/-
,, fdry. No. 3	59/6
,, basic	60/-
Scotland—	
Foundry No. 1	75/-
,, No. 3	70/-
Hem. M/Nos.	74/-
Sheffield (d/d district)—	
Derby forge	61/6
,, fdry. No. 3	64/-
Lincs. forge	62/6
,, fdry. No. 3	64/-
E.C. hematite	78/6
W.C. hematite	84/6
Lincs. (at furnaces)—	
Forge No. 4	58/-
Foundry No. 3	59/6
Basic	59/-
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	67/6
Northants foundry No. 3	—
Dalzell, No. 3(special)	100/- to 102/6
Summerlee, No. 3	87/6 to 90/-
Glengarnock, No. 3	87/6 to 90/-
Gartsherrie, No. 3	87/6 to 90/-
Monkland, No. 3	87/6 to 90/-
Shotts, No. 3	87/6 to 90/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.) nom.	9 10 0	to 10 15 0
Nut and bolt iron	8 12 6	to 8 17 6
Hoops	11 10 0	
Marked bars (Staffs.) f.o.t.	12 0 0	
Gas strip	11 10 0	
Bolts and nuts, ¾ in. × 4 in.	15 5 0	
Steel—		
Ship plates	8 7 6	to 8 12 6
Boiler plts.	10 10 0	
Chequer plts.	10 12 6	
Angles	7 17 6	
Tees	8 17 6	
Joists	7 17 6	
Rounds and squares, 3 in. to 5½ in.	8 17 6	
Rounds under 3 in. to ¾ in. (Untested)	7 15 0	and upwards
Flats, over 5 in. wide and up	8 7 6	
Flats, 5 in. to 1½ in.	7 17 6	
Rails, heavy	8 10 0	
Fishplates	12 10 0	
Hoops (Staffs.)	10 0 0	
Black sheets, 24g.	10 0 0	
Galv. cor. shts., 24g.	13 10 0	
Galv. fencing wire 8g. plain	12 10 0	
Billets, soft	6 2 6	to 6 10 0
Billets, hard	7 2 6	to 7 12 6
Sheet bars	6 0 0	
Tin bars	6 0 0	

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 2½
Sheet to 10 w.g.	1 3
Wire	1 3½
Rods	1 3
Tubes	1 7½
Castings	1 2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	20.26
No. 2 foundry, Valley	17.00
No. 2 foundry, Birm.	16.25
Basic	18.02
Bessemer	19.01
Malleable	19.01
Grey forge	18.26
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bess billets	32.00
O.-h. billets	32.00
O.-h. sheet bars	32.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.90
Tank plates	1.90
Beams, etc.	1.96
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.65
Sheets, galv., No. 24	3.40
Sheets, blue an'l'd., 9 and 10	2.00
Wire nails	2.55
Plain wire	2.40
Barbed wire, galv.	3.20
Tinplates, 100 lb. box	$5.25

COKE (at ovens).

Welsh foundry	25/- to 35/-
,, furnace	19/- to 21/-
Durham and North.	
,, foundry	15/- to 15/6
,, furnace	14/-
Midlands, foundry	—
,, ,, furnace	12/- to 13/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box	18/- to 18/3	
,,	28×20	,,	36/3
,,	20×10	,,	27/-
,,	18½×14	,,	18/9
C.W.	20×14	,,	15/6
,,	28×20	,,	33/6
,,	20×10	,,	22/-
,,	18½×14	,,	15/9
Terneplates	28×20		33/6 per box basis f.o.b.

SWEDISH IRON.

Bars, hammered, £17 10 0	to £18 10 0
Rolled Ord. £15 0 0	to £15 10 0
Nail rods £15 7 6	to £15 15 0
Keg. steel nom.	£32 to £33
Faggot steel nom.	£22 to £25
Blooms, according to quality	£8 to £12
Pig-iron £5 15 0	to £6 0 0

all f.o.b. Gothenburg

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	Fittings.
Gas	67½%	50%
Water	63½%	45%
Steam	60%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
Sept. 20 ..	64	1	3	inc.	3/-
,, 21 ..	64	8	9	,,	7/6
,, 24 ..	64	10	0	,,	1/3
,, 25 ..	64	12	6	,,	2/6
,, 26 ..	64	11	3	dec.	1/3

Electrolytic Copper.

	£	s.	d.	
Sept. 20 ..	70	5	0	No change
,, 21 ..	70	15	0	inc. 10/-
,, 24 ..	71	5	0	inc. 10/-
,, 25 ..	71	5	0	No change
,, 26 ..	71	5	0	,, ,,

Standard Tin (cash).

	£	s.	d.	
Sept. 20 ..	216	15	0	dec. 20/-
,, 21 ..	219	5	0	inc. 50/-
,, 24 ..	220	7	6	,, 22/6
,, 25 ..	223	10	0	,, 62/6
,, 26 ..	223	0	0	dec. 10/-

Tin (English ingots).

	£	s.	d.	
Sept. 20 ..	216	5	0	dec. 30/-
,, 21 ..	219	0	0	inc. 55/-
,, 24 ..	219	0	0	No change
,, 25 ..	222	0	0	inc. 60/-
,, 26 ..	222	10	0	,, 10/-

Zinc Sheets (English).

	£	s.	d.	
Sept. 20 ..	33	0	0	No change
,, 21 ..	33	0	0	,, ,,
,, 24 ..	33	0	0	,, ,,
,, 25 ..	33	0	0	,, ,,
,, 26 ..	33	0	0	,, ,,

Spelter (ordinary).

	£	s.	d.	
Sept. 20 ..	24	7	6	dec. 1/6
,, 21 ..	24	7	6	No change
,, 24 ..	24	6	3	dec. 1/3
,, 25 ..	24	6	3	No change
,, 26 ..	24	2	6	dec. 3/9

Lead (English).

	£	s.	d.	
Sept. 20 ..	23	10	0	No change
,, 21 ..	23	10	0	,, ,,
,, 24 ..	23	5	0	dec. 5/-
,, 25 ..	23	5	0	No change
,, 26 ..	23	5	0	,, ,,

AVERAGE PRICES OF GALVANISED CORRUGATED SHEETS (NORTH OF ENGLAND).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1901.....	13 0 0	12 5 0	11 10 0	11 16 0	11 10 0	11 10 0	11 10 0	11 10 0	12 0 0	12 0 0	12 0 0	12 0 0	11 17 1
1902.....	12 0 0	11 10 0	11 10 0	11 10 0	11 15 0	11 15 0	11 15 0	11 15 0	11 15 0	11 15 0	11 15 0	11 15 0	11 14 2
1903.....	11 5 0	11 5 0	11 5 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 5 0	11 5 0	11 5 0	11 5 0	11 7 1
1904.....	11 5 0	11 5 0	11 5 0	11 5 0	10 15 0	10 15 0	10 15 0	10 15 0	10 5 0	10 5 0	10 5 0	10 5 0	10 15 0
1905.....	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	11 0 0	11 5 0	11 15 0	12 0 0	10 15 0
1906.....	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 12 6	12 12 6	12 15 0	12 15 0	12 15 0	13 5 0	12 12 11½
1907.....	13 5 0	13 5 0	13 15 0	13 15 0	13 15 0	13 15 0	13 17 6	13 17 6	13 17 6	13 2 6	13 2 6	13 2 6	13 10 10
1908.....	13 2 6	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 11 0½
1909.....	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 16 8
1910.....	11 15 0	12 5 0	12 5 0	11 15 0	11 10 0	11 10 0	11 12 6	11 12 6	11 12 6	11 12 6	11 10 0	11 10 0	11 13 4
1911.....	11 5 0	11 1 3	10 15 0	10 15 0	10 13 9	10 10 0	10 13 9	11 0 0	11 5 0	11 5 0	11 5 0	11 7 0	10 19 7½
1912.....	11 10 0	11 10 0	11 10 0	11 15 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 12 6	12 18 0	12 15 0	12 2 11½
1913.....	12 15 0	12 15 0	12 15 0	12 11 3	11 18 0	11 15 0	11 15 0	11 15 0	11 15 0	11 3 0	11 0 0	11 2 6	11 18 4
1914.....	11 7 0	11 7 6	11 7 6	11 5 7½	11 2 6	10 15 0	10 15 0	12 17 6	14 2 0	13 7 0	11 15 7	11 2 6	11 16 0
1915.....	11 10 8½	13 12 6	14 8 9	15 0 6	17 17 6	20 17 6	20 17 6	20 6 3	17 12 6	18 1 0	22 13 9	25 2 0	18 3 4½
1916.....	26 5 0	27 12 6	28 0 0	28 5 0	29 0 0	29 0 0	28 15 0	28 3 0	28 15 0	28 15 0	28 15 0	28 15 0	28 6 8½
1917.....	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 0 0	28 0 0	28 0 0	28 11 3
1918.....	28 5 0	28 15 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	28 13 4
1919.....	29 0 0	29 0 0	29 0 0	28 0 0	28 10 0	27 7 6	27 5 0	29 3 0	32 0 0	33 0 0	36 10 0	40 8 4	31 5 3½
1920.....	46 10 0	49 15 0	53 15 0	56 0 0	55 10 0	54 10 0	52 10 0	48 10 0	44 3 4	39 2 6	35 17 6	30 8 0	47 4 3
1921.....	28 10 0	25 17 6	24 5 0	23 3 4	22 0 0	22 0 0	23 10 0	21 12 6	20 0 0	18 15 0	18 3 9	17 2 0	22 1 7
1922.....	16 17 6	15 13 9	16 3 0	16 10 0	16 4 4½	15 15 6	15 16 3	16 16 0	16 8 9	16 6 3	17 1 0	17 7 6	16 7 5½
1923.....	18 3 1½	19 1 11½	19 8 0	19 10 0	19 7 0	19 1 3	18 0 0	18 13 1½	19 0 0	19 3 9	19 2 6	18 19 4½	18 19 2
1924.....	18 13 6	18 9 4½	18 5 0	17 15 11½	17 3 0	17 19 4½	18 7 6	18 8 1½	17 19 6	17 11 3	17 10 0	18 0 10½	
1925.....	17 8 6	17 1 6½	16 9 4½	16 12 0	16 9 8½	16 9 4½	16 0 6	16 1 10½	16 5 0	16 7 0	16 12 6	16 15 0	16 11 0½
1926.....	16 14 4½	16 5 7½	16 0 6	15 11 10½	15 11 3	16 0 0	16 16 0	16 18 9	16 14 0	16 18 9	17 10 0	16 19 0	16 10 0½
1927.....	16 3 1½	15 7 6	15 3 3	15 3 1½	14 14 4½	14 11 6	14 1 10½	14 0 0	13 19 6	13 16 10½	13 13 1½	13 3 9	14 9 10
1928.....	13 0	13 2 6	13 6 0	13 2 6	13 3 0	13 6 9	13 11 3	13 10 0	—	—	—	—	—

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

PIG IRON

REGISTERED TRADE MARK

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

19, ST. VINCENT PLACE, GLASGOW.

ZETLAND ROAD, MIDDLESBROUGH.

SMALL ADVERTISEMENTS.

Notice.

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED.

SENIOR Electric Welder (Carbon Arc) desires change; 13 years' experience; age 28; steel foundry preferred.—Apply, Box 826, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

EXPERIENCED Engineer and Foundry Manager desires position; practical and theoretical training; expert in use of moulding machines and design of pattern plates; also cupola control and metal mixing, heavy or light work; highest references for integrity and ability.—Box 814, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

QUALCAST, LIMITED, Specialists in Machine Moulded Light, Grey Iron Castings, are erecting a new and thoroughly up-to-date Foundry, and require an Assistant Foundry Foreman.—Apply by letter, stating age, experience and salary required to Works Manager, Qualcast, Limited, Derby.

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